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PHS TERMINAL DEVICE AND DATA COLLECTION SYSTEM USING THE SAME

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(57) Claim

1. A data collection system comprising:

plural machines for generating data pieces respectively;

PHS terminal devices connected to the machines for transmitting the data pieces generated by the machines respectively, the PHS terminal devices composing a PHS communication network; and

a center apparatus for collecting the data pieces from the machines via the PHS terminal devices;

wherein paths of data-piece transmission are selected in the PHS communication network, and the data pieces are transmitted from the machines toward the center apparatus along the selected paths while being repeated by at least one of the PHS terminal devices.

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30. A PHS terminal device comprising:

a communication unit for receiving data from a data generating machine;

a memory for storing the received data;

a radio unit for transmitting the data to a PHS communication network by radio; and

means for selecting a path of data transmission in the PHS communication network, and allowing the selected path to be used in the transmission of the data from the radio unit.

31. A data collection system comprising:

a first machine generating a first data piece;

a second machine generating a second data piece;

a first slave PHS terminal device connected to the first machine and receiving the first data piece from the first machine, the first slave PHS terminal device transmitting the first data piece by radio;

a second slave PHS terminal device connected to the second machine and receiving the second data piece from the second machine, the second slave PHS terminal device transmitting the second data piece by radio;

a center apparatus; and

a master PHS terminal device connected to the first slave PHS terminal device via a radio path and receiving the first data piece from the first slave PHS terminal device by radio, the master PHS terminal device being connected to the second slave PHS terminal device via a radio path and receiving the second data piece from the

second slave PHS terminal device by radio, the master PHS terminal device being connected to the center apparatus via a public telephone line and transmitting the first data piece and the second data piece to the center apparatus via the public telephone line.

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ORIGINAL

COMPLETE SPECIFICATION

STANDARD PATENT

Invention Title: PHS TERMINAL DEVICE AND DATA COLLECTION SYSTEM USING THE SAME

The following statement is a full description of this invention, including the best method of performing it known to us:

GH REF: P11602-EB:TJSRK

TITLE OF THE INVENTION

PHS TERMINAL DEVICE AND

DATA COLLECTION SYSTEM USING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a PHS (personal handy phone system) terminal device. This invention also relates to a data collection system using PHS terminal devices.

Description of the Related Art

In a known data collection system, data are sent to a central point from one or more locations via a public telephone network. Generally, the central point has a host computer while the locations have terminal devices for inputting data. In the central point, the host computer can be connected to the public telephone network via a communication device. In the locations, the terminal devices can be connected to the public telephone network via communication devices. For example, the central point is a main office, and the locations correspond to sub offices. The sent data represent, for example, the sales in the respective sub offices.

The known data collection system tends to use the public telephone network at a high frequency. The high-frequency use of the public telephone network is a great expense.

SUMMARY OF THE INVENTION

It is preferably an advantage of this invention to provide an improved PHS terminal device.

It is preferably another advantage of this invention to provide an improved

[illegible]

[illegible] the machines [illegible] the machines respectively, the PHS terminal [illegible] comprising a PHS communication network; and a center apparatus for collecting the data pieces from the machines via the PHS terminal devices; wherein paths of data-piece transmission are selected in the PHS communication network, and the data pieces are transmitted from the machines toward the center apparatus along the selected paths while being repeated by at least one of the PHS terminal devices.

A second aspect of this invention is based on the first aspect thereof, and provides a data collection system wherein each of the PHS terminal devices includes a communication unit for receiving the data piece from a related machine, a memory for storing the received data piece, a radio unit for transmitting the data piece to the PHS communication network by radio, and means for selecting a path of data-piece transmission in the PHS communication network.

A third aspect of this invention is based on the first aspect thereof, and provides a data collection system wherein the selected paths of data-piece transmission correspond to higher electric-field strengths than electric-field strengths related to non-selected paths.

A fourth aspect of this invention is based on the third aspect thereof, and provides a data collection system wherein at least one

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of the PHS terminal devices which implements a repeating process uses one of a transceiver function and a PHS communication function in the repeating process.

A fifth aspect of this invention is based on the third aspect or the fourth aspect thereof, and provides a data collection system wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, the master PHS terminal device collecting the data pieces from the machines via the slave PHS terminal devices, the master PHS terminal device transmitting the collected data pieces to the center apparatus.

A sixth aspect of this invention is based on the third aspect thereof, and provides a data collection system wherein each of the PHS terminal devices has an entry table of information pieces representing conditions of all the PHS terminal devices.

A seventh aspect of this invention is based on the sixth aspect thereof, and provides a data collection system wherein each of the PHS terminal devices has a connection table of information pieces representing conditions of radio connections among all the PHS terminal devices.

An eighth aspect of this invention is based on the seventh aspect thereof, and provides a data collection system wherein the conditions of the radio connections in the connection table are denoted by numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A ninth aspect of this invention is based on the eighth aspect thereof, and provides a data collection system wherein the numeral

values in the connection table are determined on the basis of electric-field strengths related to the radio connections.

A tenth aspect of this invention is based on the eighth aspect or the ninth aspect thereof, and provides a data collection system wherein each of the PHS terminal devices deletes a smallest non-zero numeral value from the numeral values in the connection table to change the connection table into a new version, and selects a path of data-piece transmission in response to the new connection table.

An eleventh aspect of this invention is based on the tenth aspect thereof, and provides a data collection system wherein each of the PHS terminal devices deletes a smallest non-zero numeral value from the numeral values in the connection table to change the connection table into a first new version, and wherein each of the PHS terminal devices deletes a smallest non-zero numeral value from the numeral values in the first new connection table to change the first new connection table into a second new version and selects a path of data-piece transmission in response to the second new connection table.

A twelfth aspect of this invention is based on the eleventh aspect thereof, and provides a data collection system wherein when each of the PHS terminal devices fails to select a path of data-piece transmission in response to the second new connection table, the PHS terminal device returns the second new connection table to the first new connection table and selects a path of data-piece transmission in response to the first new connection table.

A thirteenth aspect of this invention is based on one of the tenth aspect, the eleventh aspect, and the twelfth aspect thereof, and provides a data collection system wherein each of the PHS terminal devices generates a transmission-path deducing table on the basis of the connection table, and selects a path of data-piece transmission in response to the transmission-path deducing table.

A fourteenth aspect of this invention is based on the eighth aspect thereof, and provides a data collection system wherein the PHS terminal devices communicate with each other by radio to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A fifteenth aspect of this invention is based on the eighth aspect thereof, and provides a data collection system wherein the PHS terminal devices communicate with each other by radio in a predetermined sequence and a predetermined rule to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A sixteenth aspect of this invention is based on the fifteenth aspect thereof, and provides a data collection system wherein different management numbers are assigned to the PHS terminal devices respectively, and each of the PHS terminal devices communicates with only at least one of the PHS terminal devices which has a management number greater than the management number of the present PHS terminal device to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A seventeenth aspect of this invention is based on the fifteenth aspect thereof, and provides a data collection system wherein different management numbers are assigned to the PHS terminal devices respectively, and each of the PHS terminal devices communicates with only at least one of the PHS terminal devices which has a management number smaller than the management number of the present PHS terminal device to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

An eighteenth aspect of this invention is based on the sixteenth aspect or the seventeenth aspect thereof, and provides a data collection system wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, and each of the PHS terminal devices communicates with the master PHS terminal device regardless of the management number thereof to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A nineteenth aspect of this invention is based on any one of the sixteenth aspect, the seventeenth aspect, and the eighteenth aspect thereof, and provides a data collection system wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, and the master PHS terminal device does not communicate with the other PHS terminal devices to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A twentieth aspect of this invention is based on any one of the

fourteenth aspect, the fifteenth aspect, the sixteenth aspect, the seventeenth aspect, the eighteenth aspect, and the nineteenth aspect thereof, and provides a data collection system wherein each of the PHS terminal devices measures electric-field strengths related to the radio connections, and determines the numerical values on the basis of the measured electric-field strengths.

A twenty-first aspect of this invention is based on the fourteenth aspect or the fifteenth aspect thereof, and provides a data collection system wherein the PHS terminal devices periodically update the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A twenty-second aspect of this invention is based on the twenty-first aspect thereof, and provides a data collection system wherein the PHS terminal devices periodically update the numeral values by weighted average between previous numerical values and current numerical values.

A twenty-third aspect of this invention is based on the twenty-first aspect or the twenty-second aspect thereof, and provides a data collection system wherein the PHS terminal devices periodically update the numeral values by rewriting information pieces in portions of the connection tables about which the PHS terminal devices communicate with each other by radio to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

A twenty-fourth aspect of this invention is based on the twenty-third aspect thereof, and provides a data collection system

wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, the slave PHS terminal devices transmit the connection tables to the master PHS terminal device, the master PHS terminal device combining the transmitted connection tables into a composite connection table, the master PHS terminal devices transmitting the composite connection table to the slave PHS terminal devices.

A twenty-fifth aspect of this invention is based on any one of the twenty-first aspect, the twenty-second aspect, and the twenty-fourth aspect thereof, and provides a data collection system wherein each of the PHS terminal devices includes a timer for controlling a sequence of execution of operation modes of the related PHS terminal device.

A twenty-sixth aspect of this invention is based on the twenty-third aspect thereof, and provides a data collection system wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, and wherein one of the slave PHS terminal devices is newly added to the PHS communication network while the other slave PHS terminal devices are old members in the PHS communication network slaves, the newly-added PHS terminal device communicating with one of the old PHS terminal devices to receive the connection table therefrom, the newly-added PHS terminal device communicating with the old PHS terminal devices to generate a new connection table based on the received connection table, and the newly-added PHS terminal device transmitting the new connection table to the master PHS terminal

device.

A twenty-seventh aspect of this invention is based on the twenty-sixth aspect thereof, and provides a data collection system wherein all the slave PHS terminal devices including the newly-added PHS terminal device transmit the connection tables to the master PHS terminal device, the master PHS terminal device combining the transmitted connection tables into a revised composite connection table, the master PHS terminal devices transmitting the revised composite connection table to all the slave PHS terminal devices.

A twenty-eighth aspect of this invention is based on any one of the tenth aspect, the eleventh aspect, the twelfth aspect, and the thirteenth aspect thereof, and provides a data collection system wherein when plural paths of data-piece transmission from one of the PHS terminal devices are present, one of the plural paths in which a PHS terminal device following a branch has a smaller number is selected.

A twenty-ninth aspect of this invention is based on any one of the tenth aspect, the eleventh aspect, the twelfth aspect, and the thirteenth aspect thereof, and provides a data collection system wherein when plural paths of data-piece transmission from one of the PHS terminal devices are present, one of the plural paths which has a smaller number of repeating is selected.

A thirtieth aspect of this invention provides a PHS terminal device comprising a communication unit for receiving data from a data generating machine; a memory for storing the received data; a

radio unit for transmitting the data to a PHS communication network by radio; and means for selecting a path of data transmission in the PHS communication network, and allowing the selected path to be used in the transmission of data from the radio unit.

A thirty-first aspect of this invention provides a data collection system including a first machine generating a first data piece; a second machine generating a second data piece; a first slave PHS terminal device connected to the first machine and receiving the first data piece from the first machine, the first slave PHS terminal device transmitting the first data piece by radio; a second slave PHS terminal device connected to the second machine and receiving the second data piece from the second machine, the second slave PHS terminal device transmitting the second data piece by radio; a center apparatus; and a master PHS terminal device connected to the first slave PHS terminal device via a radio path and receiving the first data piece from t he first slave PHS terminal device by radio, the master PHS terminal device being connected to the second slave PHS terminal device via a radio path and receiving the second data piece from the second slave PHS terminal device by radio, the master PHS terminal device being connected to the center apparatus via public telephone line and transmitting the first data piece and the second data piece to the center apparatus via the public telephone line.

A thirty-second aspect of this invention is based on the thirty-first aspect thereof, and provides a data collection system further including a third machine generating a third data piece, the master PHS terminal device being connected to the third machine and receiving the third data piece from the third machine, the master PHS terminal device transmitting the third data piece in addition to the first and second data pieces to the center apparatus via the public telephone line.

A thirty-third aspect of this invention is based

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on the thirty-first aspect thereof, and provides a data collection system further including a third machine generating a third data piece, and a third slave PHS terminal device connected to the third machine and receiving the third data piece from the third machine, the third slave PHS terminal device transmitting the third data piece by radio, the first slave PHS terminal device being connected to the third slave PHS terminal device via a radio path and receiving the third data piece from the third slave PHS terminal device by radio, the first slave PHS terminal device transmitting the third data piece by radio, the master PHS terminal device receiving the third data piece in addition to the first data piece from the first slave PHS terminal device by radio, the master PHS terminal device transmitting the third data piece in addition to the first and second data pieces to the center apparatus via the public telephone line.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a block diagram of a prior-art data collection system.

Fig. 2 is a diagram of a PHS communication network in a data collection system according to a first embodiment of this invention.

Fig. 3 is a block diagram of a terminal device in Fig. 2.

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Fig. 4 is a block diagram of the data collection system according to the first embodiment of this invention.

Fig. 5 is a diagram of an example of an entry table.

Fig. 6 is a diagram of an example of a connection table.

Fig. 7 is a flowchart of a first segment of a control program for a CPU in each of PHS terminal devices in Fig. 4.

Fig. 8 is a diagram of a state of a connection table which is generated from the connection table in Fig. 6.

Fig. 9 is a diagram of a state of a connection table which is generated from the connection table in Fig. 8.

Fig. 10 is a diagram of an example of data transmission paths in the PHS communication network of Fig. 2.

Fig. 11 is a diagram of an example of data transmission paths in a second PHS communication network.

Fig. 12 is a diagram of an example of data transmission paths in a third PHS communication network.

Fig. 13 is a flowchart of a second segment of the control program for the CPU in each of the PHS terminal devices in Fig. 4.

Fig. 14 is a flowchart of the details of a block in Fig. 13.

Fig. 15 is a flowchart of a third segment of the control program for the CPU in each of the PHS terminal devices in Fig. 4.

Fig. 16 is a flowchart of a fourth segment of the control program for the CPU in each of the PHS terminal devices in Fig. 4.

Fig. 17 is a flowchart of a segment of a control program for a CPU in each of PHS terminal devices in a data collection system according to a second embodiment of this invention.

Fig. 18 is a flowchart of another segment of the control program for the CPU in the second embodiment of this invention.

Fig. 19 is a diagram of a PHS communication network in a data collection system according to a third embodiment of this invention.

Fig. 20 is a time-domain diagram of a sequence of radio communications among PHS terminal devices in Fig. 19.

Fig. 21 is a diagram of a PHS communication network in a data collection system according to a fourth embodiment of this invention.

Fig. 22 is a time-domain diagram of a sequence of radio communications among PHS terminal devices in Fig. 21.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A prior-art data collection system will be explained hereinafter for a better understanding of this invention.

Fig. 1 shows a prior-art data collection system which has a center 1. A computer 2 is located in the center 1. The computer 2 is provided with a communication device 3. The prior-art data collection system also has branches in which data generating devices 4a, 4b, 4c, and 4d are placed respectively. The data generating devices 4a, 4b, 4c, and 4d are provided with communication devices 5a, 5b, 5c, and 5d respectively. The computer 2 in the center 1 can be connected to a public telephone network via the communication device 3. Similarly, the data generating devices 4a, 4b, 4c, and 4d in the branches can be connected to the public telephone network via the communication devices 5a, 5b, 5c, and 5d. Accordingly, the computer 2 in the

center 1 can communicate with the data generating devices 4a, 4b, 4c, and 4d in the branches via the public telephone network.

The prior-art data collection system of Fig. 1 operates as follows. The center 1 makes a telephone call to the first branch and then the computer 2 in the center 1 communicates with the data generating device 4a in the first branch via the public telephone network. During the communication, data is transmitted from the data generating device 4a to the computer 2 via the public telephone network. Subsequently, the center 1 makes a telephone call to the second branch and then the computer 2 in the center 1 communicates with the data generating device 4b in the second branch via the public telephone network. During the communication, data is transmitted from the data generating device 4b to the computer 2 via the public telephone network. Similarly, the center 1 sequentially accesses the third and fourth branches, and sequentially receives data from the third and fourth branches.

In the prior-art data collection system of Fig. 1, the center 1 makes at least four telephone calls during one cycle of the collection of data from the four branches. Thus, the prior-art data collection system tends to use the public telephone network at a high frequency. The high-frequency use of the public telephone network is a great expense.

First Embodiment

This invention will be explained in detail hereinafter. With reference to Fig. 2, a data collection system according to a first embodiment of this invention includes a PHS (personal handy phone

system) communication network in which PHS terminal devices "A", "B", "C", "D", and "E" form nodes respectively. The PHS communication network is a charge-free private radio communication network. The PHS terminal device "A" is a master while the PHS terminal devices "B", "C", "D", and "E" are slaves to the master.

In Fig. 2, the solid lines connecting the PHS terminal devices "B", "C", "D", and "E" denote radio communication lines via which the PHS terminal devices can directly communicate with each other by radio.

Under an example of conditions, the direct radio communication between the PHS terminal devices "A" and "B" relates to an electric-field strength of 35 dBμ, and has a reliability degree (a reliability level) of "10" which is determined on the basis of the electric-field strength. The electric-field strength means the strength of electric field of received radio wave transmitted from one of the PHS terminal devices "A" and "B" to the other. The direct radio communication between the PHS terminal devices "A" and "D" relates to an electric-field strength of 24 dBμ, and has a reliability degree (a reliability level) of "6". The direct radio communication between the PHS terminal devices "B" and "C" relates to an electric-field strength of 43 dBμ, and has a reliability degree (a reliability level) of "13". The direct radio communication between the PHS terminal devices "B" and "D" relates to an electric-field strength of 28 dBμ, and has a reliability degree (a reliability level) of "8". The direct radio communication between the PHS

terminal devices "C" and "D" relates to an electric-field strength of 35 dBμ, and has a reliability degree (a reliability level) of "10". The direct radio communication between the PHS terminal devices "C" and "E" relates to an electric-field strength of 33 dBμ, and has a reliability degree (a reliability level) of "10". The direct radio communication between the PHS terminal devices "D" and "E" relates to an electric-field strength of 20 dBμ, and has a reliability degree (a reliability level) of "4".

The PHS terminal devices "A", "B", "C", "D", and "E" have similar structures. Accordingly, only the PHS terminal device "A" will be explained in detail.

As shown in Fig. 3, the PHS terminal device "A" includes a central processing unit (CPU) 11, memories 12, 13, 14, a lamp or an indicator 15, a clock 16, a display 17A, a keyboard 17B, communication units 18, 19, 20, and 21, a modem 25, a radio unit (a radio transmitter and a radio receiver) 26, and an antenna 27.

The memories 12, 13, 14, the lamp 15, the clock 16, the display 17A, the keyboard 17B, the communication units 18, 19, 20, and 21 are connected to the CPU 11. The communication unit 18 is connected to the modem 25. The modem 25 is connected to the radio unit 26. The radio unit 26 is connected to the antenna 27.

The communication unit 19 can be connected to an external modem 22 via a terminal or a port 28. The modem 22 is connected to a line of a wire communication network such as a public wire telephone network. The communication unit 20 can be connected to an external device 23 via a terminal or a port 29. The connection

between the communication unit 20 and the external device 23 includes a communication line (a communication wire). The communication unit 21 can be connected to a maintenance terminal device 24 via a terminal or a port 30. The connection between the communication unit 21 and the maintenance terminal device 24 includes a communication line (a communication wire).

The CPU 11 controls the memory 13, the lamp 15, the display 17A, and the communication units 18, 19, 20, and 21. The memory 12 stores a control program for the CPU 11. The CPU 11 operates in accordance with the control program. The memory 13 is used to store data. The memory 14 stores various control information pieces. The CPU 11 refers to the control information pieces in the memory 14 during operation thereof. The lamp 15 is used to indicate conditions of operation of the PHS terminal device "A". The clock 16 generates timer signals and timing signals, and feeds the generated timer signals and the generated timing signals to the CPU 11. To this end, the clock 16 includes a timer or timers. The CPU 11 executes or implements different works (different control-program segments) in a sequence determined by the timer signals and the timing signals fed from the clock 16. The display 17A is used to indicate various data pieces. The keyboard 17B is used to input various operation commands to the CPU 11.

Data can be transmitted between the memory 13 and the radio unit 26 via the CPU 11, the communication unit 18, and the modem 25. The radio unit 26 can generate a radio signal of the PHS format which carries data fed via the modem 25 and the

communication unit 18. The radio unit 26 feeds the generated radio signal to the antenna 27. The radio signal is radiated by the antenna 27. A radio signal of the PHS format which carries data can be received by the antenna 27. The received radio signal is fed from the antenna 27 to the radio unit 26. The radio unit 26 recovers the data from the radio signal. The recovered data can be transmitted from the radio unit 26 to the CPU 11 via the modem 25 and the communication unit 18. In addition, the radio unit 26 detects the strength of electric field of the received radio signal. The radio unit 26 feeds information of the detected electric-field strength to the CPU 11 via the modem 25 and the communication unit 18. The radio unit 26 may directly feed the information of the detected electric-field strength to the CPU 11.

Data can be transmitted between the memory 13 and the communication unit 19 via the CPU 11. The communication unit 19 can transmit and receive data to and from the line of the wire communication network (the public wire telephone network) via the modem 22.

Data can be transmitted between the memory 13 and the communication unit 20 via the CPU 11. The communication unit 20 can transmit and receive data to and from the external device 23 via the communication line (the communication wire). The external device 23 is, for example, a microcomputer within an apparatus.

Data can be transmitted between the memory 13 and the communication unit 21 via the CPU 11. The communication unit 21 can transmit and receive data to and from the maintenance terminal

device 24 via the communication line (the communication wire). The maintenance terminal device 24 serves to check operation of each portion of the PHS terminal device "A". A personal computer can be used as the maintenance terminal device 24.

With reference to Fig. 4, a branch business office 100 has automatic vending machines 101A, 101B, 101C, 101D, and 101E. The automatic vending machines 101A, 101B, 101C, 101D, and 101E include microcomputers 102A, 102B, 102C, 102D, and 102E, respectively. Each of the microcomputers 102A, 102B, 102C, 102D, and 102E is programmed to implement the following processes. Upon each selling, the microcomputer (102A, 102B, 102C, 102D, or 102E) generates data representing the name of a sold item, the sales number of the item, the amount of received money, the amount of change, and the present date and time (that is, the date and time of each selling). The microcomputer (102A, 102B, 102C, 102D, or 102E) stores the generated data in an internal memory.

In the branch business office 100, the PHS terminal devices "A", "B", "C", "D", and "E" are connected to the microcomputers 102A, 102B, 102C, 102D, and 102E of the automatic vending machines 101A, 101B, 101C, 101D, and 101E via the terminals 29 (see Fig. 3), respectively. The microcomputers 102A, 102B, 102C, 102D, and 102E correspond to the external device 23 in Fig. 3. According to the control programs in the memories 12 (see Fig. 3), the CPU's 11 (see Fig. 3) in the PHS terminal devices "A", "B", "C", "D", and "E" operate to iteratively fetch data from the

microcomputers 102A, 102B, 102C, 102D, and 102E via the communication units 20 (see Fig. 3), and to iteratively store the fetched data into the memories 13 (see Fig. 3) at a predetermined period.

As previously indicated, the PHS terminal device "A" is a master while the PHS terminal devices "B", "C", "D", and "E" are slaves to the master. In the slave PHS terminal devices "B", "C", "D", and "E", according to the control programs in the memories 12, the CPU's 11 operate to iteratively transmit the data from the memories 13 to the radio units 26 (see Fig. 3) via the communication units 18 (see Fig. 3) and the modems 25 (see Fig. 3) at the predetermined period. In the slave PHS terminal devices "B", "C", "D", and "E", the radio units 26 generate radio signals of the PHS format which carry the data transmitted from the memories 13. The radio units 26 feed the generated radio signals to the antennas 27 (see Fig. 3). The radio signals are radiated by the antennas 27. The radio signals are transmitted from the slave PHS terminal devices "B", "C", "D", and "E" to the master PHS terminal device "A" along direct ways or indirect ways.

The slave PHS terminal devices "B", "C", "D", and "E" can serve as repeaters. During the repeating mode of operation of each slave PHS terminal device ("B", "C", "D", or "E"), every radio signal of the PHS format which carries data is received by the antenna 27 (see Fig. 3). The received radio signal is fed from the antenna 27 to the radio unit 26 (see Fig. 3). The radio unit 26 recovers the data from the radio signal. In the slave PHS terminal device, according to the

control program in the memory 12 (see Fig. 3), the CPU 11 (see Fig. 3) operates to transmit the recovered data from the radio unit 26 to the memory 13 (see Fig. 3) via the modem 25 and the communication unit 18. Subsequently, the slave PHS terminal device operates as follows. In the slave PHS terminal device, according to the control program in the memory 12, the CPU 11 operates to transmit the data from the memory 13 to the radio unit 26 via the communication unit 18 and the modem 25. The radio unit 26 generates a radio signal of the PHS format which carries the data transmitted from the memory 13. The radio unit 26 feeds the generated radio signal to the antenna 27. The radio signal is radiated by the antenna 27. In this way, the repeated radio signal is emitted from the slave PHS terminal device.

In the master PHS terminal device "A", every radio signal of the PHS format which carries data is received by the antenna 27 (see Fig. 3). The received radio signal is fed from the antenna 27 to the radio unit 26 (see Fig. 3). The radio unit 26 recovers the data from the radio signal. In the master PHS terminal device "A", according to the control program in the memory 12 (see Fig. 3), the CPU 11 (see Fig. 3) operates to transmit the recovered data from the radio unit 26 to the memory 13 (see Fig. 3). As a result, the data generated by the microcomputers 102A, 102B, 102C, 102D, and 102E in the automatic vending machines 101A, 101B, 101C, 101D, and 101E are transmitted to the memory 13 in the master PHS terminal device "A". In other words, the data generated by the microcomputers 102A, 102B, 102C, 102D, and 102E in the

automatic vending machines 101A, 101B, 101C, 101D, and 101E are collected into the memory 13 within the master PHS terminal device "A".

As shown in Fig. 4, a center business office 105 has a host computer 106 provided with a communication device 107. The communication device 107 is connected to a public telephone network 108. The master PHS terminal device "A" in the branch business office 100 is connected to the public telephone network 108 via the modem 22.

The host computer 106 in the center business office 105 is programmed to iteratively output a data requirement command at a predetermined period. The data requirement command is transmitted from the host computer 106 in the center business office 105 to the master PHS terminal device "A" in the branch business office 100 via the communication device 107, the public telephone network 108, and the modem 22. In the master PHS terminal device "A", the data requirement command is transmitted to the CPU 11 (see Fig. 3) via the communication unit 19 (see Fig. 3). In the master PHS terminal device "A", according to the control program in the memory 12 (see Fig. 3), the CPU 11 operates to read out the data from the memory 13 (see Fig. 3) in response to the data requirement command, and to transmit the readout data to the host computer 106 in the center business office 105 via the modem 22, the public telephone network 108, and the communication device 107. As a result, the data generated by the microcomputers 102A, 102B, 102C, 102D, and 102E in the automatic vending machines

101A, 101B, 101C, 101D, and 101E within the branch business office 100 are transmitted via the public telephone network 108 to the host computer 106 within the center business office 105 at once. Thus, the data generated by the microcomputers 102A, 102B, 102C, 102D, and 102E in the automatic vending machines 101A, 101B, 101C, 101D, and 101E within the branch business office 100 are collected in the host computer 106 within the center business office 105. The host computer 106 in the center business office 105 is programmed to analyze the data transmitted from the branch business office 100. The result of the analyzation can be used for the supply of items to the automatic vending machines 101A, 101B, 101C, 101D, and 101E in the branch business office 100, and also the maintenance of the automatic vending machines 101A, 101B, 101C, 101D, and 101E.

In the PHS terminal devices "A", "B", "C", "D", and "E", according to the control programs in the memories 12, the CPU's 11 operate to provide entry tables 41 and connection tables 42 in the memories 13. An example of the entry tables 41 is shown in Fig. 5. An example of the connection tables 42 is shown in Fig. 6.

With reference to Fig. 5, each entry table 41 stores signals representing conditions and parameters of all the PHS terminal devices "A", "B", "C", "D", and "E". The entry table 41 is divided into areas 41a, 41b, 41c, and 41d. The area 41a stores signals representing entry numbers "1", "2", "3", "4", and "5" assigned to the PHS terminal devices "C", "A", "B", "E", and "D", respectively. The area 41b stores signals representing management numbers "6",

"10", "18", "21", and "25" assigned to the PHS terminal devices "C", "A", "B", "E", and "D", respectively. The area 41c stores signals representing PS numbers (telephone numbers) "16", "21", "39", "42", and "47" assigned to the PHS terminal devices "C", "A", "B", "E", and "D", respectively. The area 41d stores signals representing the types of the PHS terminal devices "A", "B", "C", "D", and "E". Specifically, each signal in the area 41d indicates whether the related PHS terminal device is a master or a slave. For example, a signal state of "1" corresponds to a master while a signal state of "0" corresponds to a slave.

With reference to Fig. 6, each connection table 42 stores signals representing conditions of radio connections among all the PHS terminal devices "A", "B", "C", "D", and "E". The conditions of the radio connections relate to whether or not the PHS terminal devices "A", "B", "C", "D", and "E" can be connected to each other by radio. Also, the conditions of the radio connections relate to the degrees of the reliabilities of the data transmissions among the PHS terminal devices "A", "B", "C", "D", and "E". Rows in the connection table 42 are sequentially assigned to the PHS terminal devices "A", "B", "C", "D", and "E". Also, columns in the connection table 42 are sequentially assigned to the PHS terminal devices "A", "B", "C", "D", and "E". Each of cells defined by the rows and the columns stores a signal representing the condition of the radio connection between the related two PHS terminal devices among the PHS terminal devices "A", "B", "C", "D", and "E". Signals stored in the cells are referred to as connection level signals. A connection level signal of

"0" in a cell indicates that the related two PHS terminal devices can not be connected by radio. On the other hand, a non-zero connection level signal in a cell indicates that the related two PHS terminal devices can be connected by radio. The value represented by the non-zero connection level signal is in the range of "1" to "15". This value denotes the degree of the reliability of the data transmission between the related two PHS terminal devices. A greater value denotes a higher degree of the reliability. The value represented by the non-zero connection level signal is determined on the basis of the electric-field strength which is the strength of electric field of received radio wave transmitted from one of the related two PHS terminal devices to the other.

Specifically, the value represented by the non-zero connection level signal is set to "1" when the electric-field strength is equal to or smaller than 15 dBμ. The value represented by the non-zero connection level signal is set to "2" when the electric-field strength is in the range between 15 dBμ and 17 dBμ. The value represented by the non-zero connection level signal is set to "3" when the electric-field strength is in the range between 17 dBμ and 19 dBμ. The value represented by the non-zero connection level signal is set to "4" when the electric-field strength is in the range between 19 dBμ and 21 dBμ. The value represented by the non-zero connection level signal is set to "5" when the electric-field strength is in the range between 21 dBμ and 23 dBμ. The value represented by the non-zero connection level signal is set to "6" when the electric-field strength is in the range between 23 dBμ and 25 dBμ. The value

represented by the non-zero connection level signal is set to "7" when the electric-field strength is in the range between 25 dBμ and 27 dBμ. The value represented by the non-zero connection level signal is set to "8" when the electric-field strength is in the range between 27 dBμ and 29 dBμ. The value represented by the non-zero connection level signal is set to "9" when the electric-field strength is in the range between 29 dBμ and 32 dBμ. The value represented by the non-zero connection level signal is set to "10" when the electric-field strength is in the range between 32 dBμ and 35 dBμ. The value represented by the non-zero connection level signal is set to "11" when the electric-field strength is in the range between 35 dBμ and 38 dBμ. The value represented by the non-zero connection level signal is set to "12" when the electric-field strength is in the range between 38 dBμ and 42 dBμ. The value represented by the non-zero connection level signal is set to "13" when the electric-field strength is in the range between 42 dBμ and 46 dBμ. The value represented by the non-zero connection level signal is set to "14" when the electric-field strength is in the range between 46 dBμ and 50 dBμ. The value represented by the non-zero connection level signal is set to "15" when the electric-field strength is greater than 50 dBμ.

According to the control programs in the memories 12, the PHS terminal devices "A", "B", "C", "D", and "E" implement a connection-table making mode of operation. During the connection-table making mode of operation, the PHS terminal devices "A", "B", "C", "D", and "E" communicate with each other by

radio. For example, the PHS terminal device "A" transmits and receives test radio signals to and from each of the PHS terminal devices "B", "C", "D", and "E". Similarly, the PHS terminal devices "B", "C", "D", and "E" transmit and receive test radio signals. When the PHS terminal device "A" receives test radio signals from the PHS terminal devices "B", "C", "D", and "E", the radio unit 26 in the PHS terminal device "A" detects the strengths of electric fields of the received test radio signals and informs the CPU 11 of the detected electric-field strengths via the modem 25 and the communication unit 18. The CPU 11 in the PHS terminal device "A" sets the values represented by connection level signals in accordance with the detected electric-field strengths. The CPU 11 in the PHS terminal device "A" writes the connection level signals in the related cells of the connection table 42. In the case of the PHS terminal device "A", the connection level signals relate to the radio connection between the PHS terminal devices "A" and "B", the radio connection between the PHS terminal devices "A" and "C", the radio connection between the PHS terminal devices "A" and "D", and the radio connection between the PHS terminal devices "A" and "E". Similarly, the PHS terminal devices "B", "C", "D", and "E" set the values represented by connection level signals, and write the connection level signals in the related cells of the connection tables 42.

During the connection-table making mode of operation, the PHS terminal devices "A", "B", "C", "D", and "E" transmit radio signals containing the connection level signals, and repeat received

radio signals. For example, the PHS terminal device "A" transmits a radio signal containing the related connection level signals to the PHS terminal devices "B", "C", "D", and "E". Similarly, the PHS terminal devices "B", "C", "D", and "E" transmit radio signals containing the related connection level signals. When the PHS terminal device "A" receives a radio signal from the PHS terminal device "B", "C", "D", or "E", the PHS terminal device "A" repeats the received radio signal and also extracts connection level signals from the received radio signal. In the PHS terminal device "A", the radio unit 26 recovers the connection level signals from the received radio signal, and transmits the connection level signals to the CPU 11 via the modem 25 and the communication unit 18. In the PHS terminal device "A", the CPU 11 writes the connection level signal in the related cells of the connection table 42. Similarly, the PHS terminal devices "B", "C", "D", and "E" writes recovered connection level signals in related cells of the connection tables 42. As a result, the connection tables 42 in the PHS terminal devices "A", "B", "C", "D", and "E" are completed.

According to the control programs in the memories 12, the slave PHS terminal devices "B", "C", "D", and "E" implement a data transmission mode of operation. Fig. 7 shows a segment of the control programs which relates to the data transmission mode of operation.

As shown in Fig. 7, a first step ST1 of the program segment selects the lowest value ("4" in Fig. 6) in the connection table 42 which differs from "0". The step ST1 replaces the selected lowest

value ("4" in Fig. 6) by "0". Thus, the connection table 42 is modified into a second version. For example, the connection table 42 is changed from the state of Fig. 6 to the state of Fig. 8.

A step ST2 following the step ST1 decides whether or not the data can be transmitted from the present slave PHS terminal device (the PHS terminal devices "B", "C", "D", or "E") to the master PHS terminal device "A" by referring to the connection table 42 of the second version. When it is decided that the data can be transmitted from the present slave PHS terminal device to the master PHS terminal device "A", the program returns from the step ST2 to the step ST1. Otherwise, the program advances from the step ST2 to a step ST3.

In the case where the step ST2 decides that the data can be transmitted from the present slave PHS terminal device to the master PHS terminal device "A", the step ST1 selects the lowest value ("6" in Fig. 8) in the second-version connection table 42 which differs from "0". The step ST1 replaces the selected lowest value ("6" in Fig. 8) by "0". Thus, the second-version connection table 42 is modified into a third version. For example, the connection table 42 is changed from the state of Fig. 8 to the state of Fig. 9. After the step ST1, the program advances to the step ST2. The step ST2 decides whether or not the data can be transmitted from the present slave PHS terminal device to the master PHS terminal device "A" by referring to the connection table 42 of the third version. When it is decided that the data can be transmitted from the present slave PHS terminal device to the master PHS terminal

device "A", the program returns from the step ST2 to the step ST1. Otherwise, the program advances from the step ST2 to the step ST3.

Accordingly, the steps ST1 and ST2 are reiterated until the step ST2 decides that the data can not be transmitted from the present slave PHS terminal device to the master PHS terminal device "A".

It should be noted that the steps ST1 and ST2 may generate transmission-path deducing tables (corresponding to the connection table 42 of the second and later versions) on the basis of the connection table 42 of the first version or the original version. A path of data transmission from the present slave PHS terminal device to the master terminal device "A" can be decided by referring to the transmission-path deducing tables.

The step ST3 returns the latest version of the connection table 42 to the immediately preceding version thereof. After the step ST3, the program advances to a step ST4.

The step ST4 decides whether or not there are plural possible paths of data transmission from the present slave PHS terminal device to the master PHS terminal device "A" by referring to the current connection table 42. When it is decided that there are not plural possible paths of data transmission, that is, when it is decided that there is a single possible path of data transmission, the program advances from the step ST4 to a step ST5. When it is decided that there are plural possible paths of data transmission, the program advances from the step ST4 to a step ST6.

The step ST5 feeds the data from the memory 13 to the radio unit 26 via the communication unit 18 and the modem 25. The step ST5 controls the radio unit 26 to generate a radio signal of the PHS format which is addressed to a next PHS terminal device in the possible path of data transmission. The generated radio signal contains the data fed from the memory 13. The radio signal is fed from the radio unit 26 to the antenna 27 before being radiated thereby. After the step ST5, the current execution cycle of the program segment ends.

The step ST6 decides whether or not the plural possible paths of data transmission are equal in effective number of used repeaters therein. When it is decided that the plural possible paths of data transmission are equal in effective number of used repeaters therein, the program advances from the step ST6 to a step ST7. Otherwise, the program advances from the step ST6 to a step ST8.

The step ST7 compares the management numbers of PHS terminal devices in the possible paths of data transmission which immediately follow a branch among the possible paths. The step ST7 selects one out of the possible paths of data transmission in which a PHS terminal device following the branch has the lowest management number. The step ST7 feeds the data from the memory 13 to the radio unit 26 via the communication unit 18 and the modem 25. The step ST7 controls the radio unit 26 to generate a radio signal of the PHS format which is addressed to a next PHS terminal device in the selected possible path of data transmission. The generated radio signal contains the data fed from the memory

13. The radio signal is fed from the radio unit 26 to the antenna 27 before being radiated thereby. After the step ST7, the current execution cycle of the program segment ends.

The step ST8 compares the effective numbers of used repeaters in the respective possible paths of data transmission. The step ST8 selects one out of the possible paths which has the lowest effective number of used repeaters. The step ST8 feeds the data from the memory 13 to the radio unit 26 via the communication unit 18 and the modem 25. The step ST8 controls the radio unit 26 to generate a radio signal of the PHS format which is addressed to a next PHS terminal device in the selected possible path of data transmission. The generated radio signal contains the data fed from the memory 13. The radio signal is fed from the radio unit 26 to the antenna 27 before being radiated thereby. After the step ST8, the current execution cycle of the program segment ends.

It should be noted that the steps ST5, ST7 and ST8 may transmit data-representing radio signals by using the transceiver function of the present PHS terminal device rather than the PHS communication function thereof.

Fig. 10 shows an example of the path of data transmission from the slave PHS terminal device "E" to the master PHS terminal device "A" which is decided to be a single path by the step ST4 of Fig. 7. In Fig. 10, the thick lines denote the path of data transmission. Along this path, data is transmitted from the slave PHS terminal device "E" to the master PHS terminal device "A" via the slave PHS terminal devices "B" and "C". In this case, the slave

PHS terminal devices "B" and "C" serve as repeaters.

Fig. 11 shows an example of first and second possible paths of data transmission from the slave PHS terminal device "D" to the master PHS terminal device "A". Along the first possible path, data can be transmitted from the slave PHS terminal device "D" to the master PHS terminal device "A" via the slave PHS terminal device "B". The slave PHS terminal device "B" serves as a repeater. Along the second possible path, the data can be transmitted from the slave PHS terminal device "D" to the master PHS terminal device "A" via the slave PHS terminal device "C". The slave PHS terminal device "C" serves as a repeater. In this case, the program of Fig. 7 advances from the step ST4 to the step ST6, and then proceeds to the step ST7. The step ST7 selects the first possible path since the management number of the slave PHS terminal device "B" is smaller than that of the slave PHS terminal device "C". In Fig. 11, the thick lines denote the first possible path.

Fig. 12 shows an example of first and second possible paths of data transmission from the slave PHS terminal device "D" to the master PHS terminal device "A". Along the first possible path, data can be transmitted from the slave PHS terminal device "D" to the master PHS terminal device "A" via the slave PHS terminal device "B". The slave PHS terminal device "B" serves as a repeater. Along the second possible path, the data can be directly transmitted from the slave PHS terminal device "D" to the master PHS terminal device "A". In this case, the program of Fig. 7 advances from the step ST4 to the step ST6, and then proceeds to the step ST8. The

step ST8 selects the second possible path since the number of repeaters in the second possible path is smaller than the number of repeaters in the first possible path. In Fig. 12, the thick lines denote the second possible path.

As previously explained, according to the control programs in the memories 12, the PHS terminal devices "A", "B", "C", "D", and "E" implement a connection-table making mode of operation. Fig. 13 shows a segment of the control programs which relates to the connection-table making mode of operation. The program segment in Fig. 13 is periodically reiterated.

As shown in Fig. 13, a first step ST11 of the program segment decides whether or not the present PHS terminal device is a master. When it is decided that the present PHS terminal device is a master, the program exits from the step ST11 and then the current execution cycle of the program segment ends. Otherwise, the program advances from the step ST11 to a step ST12.

The step ST12 searches the entry table 41. A step ST13 following the step ST12 decides whether or not another PHS terminal device is present or absent by referring the result of the search. When it is decided that another PHS terminal device is present, the program advances from the step ST13 to a step ST14. Otherwise, the program exits from the step ST13 and then the current execution cycle of the program segment ends.

The step ST14 decides whether the other PHS terminal device is a master or a slave. When it is decided that the other PHS terminal device is a slave, the program advances from the step ST14

to a step ST15. When it is decided that the other PHS terminal device is a master, the program jumps from the step ST14 to a block ST16.

The step ST15 decides whether or not the management number of the other PHS terminal device is greater than the management number of the present PHS terminal device. When it is decided that the management number of the other PHS terminal device is greater than the management number of the present PHS terminal device, the program advances from the step ST15 to the block ST16. Otherwise, the program returns from the step ST15 to the step ST12 to search for still another PHS terminal device.

The block ST16 implements radio communication with the other PHS terminal device to set the connection level signal related to the radio connection between the present PHS terminal device and the other PHS terminal device. After the block ST16, the program returns to the step ST12 to search for still another PHS terminal device.

As a result, the connection level signals in the related cells in the connection table 42 are set. In other words, the related portion of the connection table 42 is completed.

The step ST15 may be modified to implement the following processes. The modification-resultant step ST15 decides whether or not the management number of the other PHS terminal device is smaller than the management number of the present PHS terminal device. When it is decided that the management number of the other PHS terminal device is smaller than the management number

of the present PHS terminal device, the program advances from the modification-resultant step ST15 to the block ST16. Otherwise, the program returns from the modification-resultant step ST15 to the step ST12 to search for still another PHS terminal device.

Fig. 14 shows the details of the block ST16 in Fig. 13. With reference to Fig. 14, a first step ST21 of the block ST16 follows the step ST14 or ST15 in Fig. 13. The step ST21 reads out the PS number (the telephone number) of the other PHS terminal device from the entry table 41. The step ST21 informs the radio unit 26 of the PS number of the other PHS terminal device via the communication unit 18 and the modem 25. The step ST21 controls the radio unit 26 to generate a radio call containing information of the PS number of the other PHS terminal device. The radio call is fed from the radio unit 26 to the antenna 27 before being radiated thereby.

A step ST22 following the step ST21 decides whether or not a radio answer to the radio call is successfully received. When it is decided that a radio answer to the radio call is successfully received, the program advances from the step ST22 to a step ST23. Otherwise, the program advances from the step ST22 to a step ST26.

The step ST23 controls the radio unit 26 to communicate with the other PHS terminal device and to receive a test radio signal therefrom. In addition, the step ST23 controls the radio unit 26 to detect the electric-field strength of the received test radio signal. The step ST23 receives information of the detected electric-field

strength of the test radio signal from the radio unit 26 via the communication unit 18 and the modem 25. The step ST23 may directly receive the information of the detected electric-field strength of the test radio signal from the radio unit 26.

A step ST24 subsequent to the step ST23 decides whether or not information of the detected electric-field strength of the test radio signal is available. When it is decided that information of the electric-field strength of the test radio signal is available, the program advances from the step ST24 to a step ST25. Otherwise, the program advances from the step ST24 to the step ST26.

The step ST25 controls the radio unit 26 to communicate with the other PHS terminal device and to periodically receive a test radio signal therefrom three times. In addition, the step ST25 controls the radio unit 26 to detect the electric-field strengths of the three received test radio signals. The step ST25 receives information of the detected electric-field strengths of the three test radio signals from the radio unit 26 via the communication unit 18 and the modem 25. The step ST25 may directly receive the information of the detected electric-field strengths of the three test radio signals from the radio unit 26. The step ST25 calculates a mean of the detected electric-field strengths of the three test radio signals. The step ST25 sets the value represented by the related connection level signal in response to the calculated mean electric-field strength. After the step ST25, the program advances to a step ST27.

The step ST26 sets the value represented by the related

connection level signal to "0". After the step ST26, the program advances to the step ST27.

The step ST27 decides whether or not the value represented by the related connection level signal was set to "0" in the immediately preceding execution cycle of the program segment. When it is decided that the value represented by the related connection level signal was set to "0" in the immediately preceding execution cycle of the program segment, the program advances from the step ST27 to a step ST28. Otherwise, the program advances from the step ST27 to a step ST29.

The step ST28 allows the value given by the step ST25 or ST26 in the current execution cycle of the program segment to be used as it is. After the step ST28, the program advances to the step ST12 in Fig. 13.

The step ST29 calculates a new value NV by referring to the following equation for a weighed average.

$$NV = (2NP + NC)/3$$

where "NP" denotes the value given by the step ST25 or ST26 in the immediately preceding execution cycle of the program segment, and "NC" denotes the value given by the step ST25 or ST26 in the current execution cycle of the program segment. The step ST29 calculates an integer by rounding the part of the new value NV below the decimal point. The step ST29 sets the value represented by the related connection level signal to the calculated integer. After the step ST29, the program advances to the step ST12 in Fig. 13.

According to the control programs in the memories 12, the

PHS terminal devices "B", "C", "D", and "E" implement a connection-table updating mode of operation. During the connection-table updating mode of operation, information pieces representing the connection tables 42 made by the PHS terminal devices "B", "C", "D", and "E" are transmitted among the PHS terminal devices "B", "C", "D", and "E" by radio. In addition, each of the connection tables 42 made by the PHS terminal devices "B", "C", "D", and "E" is updated in response to the other connection tables. Fig. 15 shows a segment of the control programs which relates to the connection-table updating mode of operation.

As shown in Fig. 15, a first step ST51 of the program segment detects the management number of a PHS terminal device (or the management numbers of PHS terminal devices) to which the information piece representing the present connection table 42 should be transmitted.

A step ST52 following the step ST51 controls the radio unit 26 to derive an information piece of a connection table (an incoming connection table) 42 from a received radio signal or information pieces of connection tables (incoming connection tables) 42 from received radio signals. The step ST52 receives the information piece of the incoming connection table 42 or the information pieces of the incoming connection tables 42 from the radio unit 26 via the communication unit 18 and the modem 25.

A step ST53 subsequent to the step ST52 reads out the connection level signals from the cells of the incoming connection table or the incoming connection tables which relate to the master

PHS terminal device "A" and the slave PHS terminal device (or devices) having a management number (or management numbers) greater than the management number detected by the step ST51. The step ST53 writes the readout connection level signals into the related cells of the present connection table 42 to update the present connection table 42. After the step ST53, the current execution cycle of the program segment ends.

According to the control programs in the memories 12, the PHS terminal devices "B", "C", "D", and "E" implement a connection-table transmission mode of operation. During the connection-table transmission mode of operation, information pieces representing the connection tables 42 made by the slave PHS terminal devices "B", "C", "D", and "E" are directly or indirectly transmitted to the master PHS terminal device "A" by radio. Fig. 16 shows a segment of the control programs which relates to the connection-table transmission mode of operation. The program segment in Fig. 16 is executed each time information representing a present connection table is transmitted to another PHS terminal device or information representing an incoming connection table is repeated and transmitted to another PHS terminal device.

As shown in Fig. 16, a first step ST61 of the program segment tries to communicate with another PHS terminal device to check radio connection therewith. After the step ST61 checks the radio connection, a step ST62 controls the radio unit 26 to generate a radio signal of the PHS format which contains information of a present connection table 42 or an incoming connection table 42

and which is addressed to the other PHS terminal device. The radio signal is fed from the radio unit 26 to the antenna 27 before being radiated thereby. After the step ST62, the current execution cycle of the program segment ends.

As previously explained, in the branch business office 100, the slave PHS terminal devices "B", "C", "D", and "E" are informed of the data generated by the microcomputers 102B, 102C, 102D, and 102E in the automatic vending machines 101B, 101C, 101D, and 101E. The slave PHS terminal devices "B", "C", "D", and "E" directly or indirectly transmit the data to the master PHS terminal device "A" via the charge-free private radio communication network (the PHS communication network). The master PHS terminal device "A" is informed of the data generated by the microcomputer 102A in the automatic vending machine 101A. Thus, the data generated by the microcomputers 102A, 102B, 102C, 102D, and 102E in the automatic vending machines 101A, 101B, 101C, 101D, and 101E are collected into the master PHS terminal device "A". Then, the master PHS terminal device "A" in the branch business office 100 transmits all the data to the host computer 106 in the center business office 105 via the public telephone network 108 at once. This process results in a less frequency of use of the public telephone network 108 which reduces the cost in comparison with the prior-art data collection system of Fig. 1. The data generated by the microcomputers 102A, 102B, 102C, 102D, and 102E in the automatic vending machines 101A, 101B, 101C, 101D, and 101E within the branch business office 100 are thus collected in the host

computer 106 within the center business office 105.

Second Embodiment

A second embodiment of this invention is similar to the first embodiment thereof except for design changes indicated hereinafter.

According to control programs in the memories 12, the PHS terminal devices "A", "B", "C", "D", and "E" implement a connection-table making mode of operation. Fig. 17 shows a segment of the control programs which relates to the connection-table making mode of operation in the second embodiment of this invention. The program segment in Fig. 17 is periodically reiterated. The program segment in Fig. 17 replaces the program segment in Fig. 13.

As shown in Fig. 17, a first step ST31 searches the entry table 41. A step ST32 following the step ST31 decides whether or not another PHS terminal device is present or absent by referring the result of the search. When it is decided that another PHS terminal device is present, the program advances from the step ST32 to a step ST33. Otherwise, the program exits from the step ST32 and then the current execution cycle of the program segment ends.

The step ST33 decides whether or not the management number of the other PHS terminal device is greater than the management number of the present PHS terminal device. When it is decided that the management number of the other PHS terminal device is greater than the management number of the present PHS terminal device, the program advances from the step ST33 to a block ST34. Otherwise, the program returns from the step ST33 to

the step ST31 to search for still another PHS terminal device.

The block ST34 implements radio communication with the other PHS terminal device to set the connection level signal related to the radio connection between the present PHS terminal device and the other PHS terminal device. After the block ST34, the program returns to the step ST31 to search for still another PHS terminal device. The block ST34 is equivalent to the block 16 in Fig. 13.

According to the control programs in the memories 12, the PHS terminal devices "A", "B", "C", "D", and "E" implement a connection-table updating mode of operation. During the connection-table updating mode of operation, information pieces representing the connection tables 42 made by the PHS terminal devices "A", "B", "C", "D", and "E" are transmitted among the PHS terminal devices "A", "B", "C", "D", and "E" by radio. In addition, each of the connection tables 42 made by the PHS terminal devices "A", "B", "C", "D", and "E" is updated in response to the other connection tables. Fig. 18 shows a segment of the control programs which relates to the connection-table updating mode of operation.

As shown in Fig. 18, a first step ST41 of the program segment detects the management number of a PHS terminal device (or the management numbers of PHS terminal devices) to which the information piece representing the present connection table 42 should be transmitted.

A step ST42 following the step ST41 controls the radio unit 26 to derive an information piece of a connection table (an incoming

connection table) 42 from a received radio signal or information pieces of connection tables (incoming connection tables) 42 from received radio signals. The step ST42 receives the information piece of the incoming connection table 42 or the information pieces of the incoming connection tables 42 from the radio unit 26 via the communication unit 18 and the modem 25.

A step ST43 subsequent to the step ST42 reads out the connection level signals from the cells of the incoming connection table or the incoming connection tables which relate to the PHS terminal device (or devices) having a management number (or management numbers) greater than the management number detected by the step ST51. The step ST53 writes the readout connection level signals into the related cells of the present connection table 42 to update the present connection table 42. After the step ST43, the current execution cycle of the program segment ends.

Third Embodiment

A third embodiment of this invention is similar to the first embodiment thereof except for design changes indicated hereinafter.

With reference to Fig. 19, the PHS terminal device "A" can communicate with the PHS terminal devices "B" and "C" by radio. The PHS terminal device "D" can communicate with only the PHS terminal device "B" by radio.

As shown in Fig. 20, information representing the connection table 42 made by the PHS terminal device "D" is transmitted from

the PHS terminal device "D" to the PHS terminal device "B" by radio. Then, the information representing the connection table 42 made by the PHS terminal device "D" is transmitted from the PHS terminal device "B" to the PHS terminal device "A" by radio. Information representing the connection table 42 made by the PHS terminal device "C" is directly transmitted from the PHS terminal device "C" to the PHS terminal device "A" by radio. Also, information representing the connection table 42 made by the PHS terminal device "B" is directly transmitted from the PHS terminal device "B" to the PHS terminal device "A" by radio.

According to a control program in the memory 12, the PHS terminal device "A" combines the connection tables 42 made by the PHS terminal devices "B", "C", and "D" into a composite connection table 42.

As shown in Fig. 20, the PHS terminal device "A" transmits information of the composite connection table 42 to the PHS terminal device "B" by radio. Then, the PHS terminal device "A" transmits the information of the composite connection table 42 to the PHS terminal device "C" by radio. The PHS terminal device "B" transmits the information of the composite connection table 42 to the PHS terminal device "D".

Fourth Embodiment

A fourth embodiment of this invention is similar to one of the first embodiment, the second embodiment, and the third embodiment thereof except for design changes indicated hereinafter.

With reference to Fig. 21, the PHS terminal device "D" is newly added to the PHS communication network having the PHS terminal devices "A", "B", and "C".

According to a control program in the memory 12, the PHS terminal device "D" communicates with the PHS terminal device "B" by radio and requests the PHS terminal device "B" to transmit information of the connection table 42 as shown in Fig. 22. Accordingly, the PHS terminal device "B" transmits the information of the connection table 42 to the PHS terminal device "D" as shown in Fig. 22.

According to the control program in the memory 12, the PHS terminal device "D" expands the connection table 42 into a new version having a row and a column assigned to the PHS terminal device "D". In addition, the PHS terminal device "D" tries to communicate with the PHS terminal devices "A", "B", and "C" by radio, and sets connection level signals related to radio connections with the terminal devices "A", "B", and "C" to complete the new connection table 42.

Specifically, as shown in Fig. 22, the PHS terminal device "D" tries to communicate with the PHS terminal device "A" by radio to set the connection level signal related to the radio connection with the PHS terminal device "A". Then, the PHS terminal device "D" tries to communicate with the PHS terminal device "B" by radio to set the connection level signal related to the radio connection with the PHS terminal device "B". Subsequently, the PHS terminal device "D" tries to communicate with the PHS terminal device "C"

by radio to set the connection level signal related to the radio connection with the PHS terminal device "C". The PHS terminal device "D" completes the new connection table 42 in response to the connection level signals related to the radio connections with the PHS terminal devices "A", "B", and "C".

As shown in Fig. 22, the PHS terminal device "D" transmits information of the new connection table 42 to the PHS terminal device "B" by radio. The PHS terminal device "B" transmits the information of the new connection table 42 to the PHS terminal device "A" by radio.

According to the control program in the memory 12, the PHS terminal device "A" updates the entry table 41 into a new version in response to the new connection table 42 transmitted from the PHS terminal device "D".

During next execution of a connection-table making and updating mode of operation, the PHS terminal devices "A", "B", "C", and "D" update the connection tables 42 into new versions. During next execution of a connection-table transmission mode of operation, the PHS terminal devices "B", "C", and "D" directly or indirectly transmit information pieces representative of the new connection tables 42 to the PHS terminal device "A" by radio. The PHS terminal device "A" combines the new connection tables 42 into a new composite connection table 42. The PHS terminal device "A" directly or indirectly transmits an information piece representative of the new composite connection table 42 and also an information piece representative of the new entry table 41 to the

PHS terminal devices "B", "C", and "D" by radio.

WHAT IS CLAIMED IS:

1. A data collection system comprising:

plural machines for generating data pieces respectively;

PHS terminal devices connected to the machines for transmitting the data pieces generated by the machines respectively, the PHS terminal devices composing a PHS communication network; and

a center apparatus for collecting the data pieces from the machines via the PHS terminal devices;

wherein paths of data-piece transmission are selected in the PHS communication network, and the data pieces are transmitted from the machines toward the center apparatus along the selected paths while being repeated by at least one of the PHS terminal devices.

2. A data collection system as recited in claim 1, wherein each of the PHS terminal devices includes a communication unit for receiving the data piece from a related machine, a memory for storing the received data piece, a radio unit for transmitting the data piece to the PHS communication network by radio, and means for selecting a path of data-piece transmission in the PHS communication network.

3. A data collection system as recited in claim 1, wherein the selected paths of data-piece transmission correspond to higher

electric-field strengths than electric-field strengths related to non-selected paths.

4. A data collection system as recited in claim 3, wherein at least one of the PHS terminal devices which implements a repeating process uses one of a transceiver function and a PHS communication function in the repeating process.

5. A data collection system as recited in claim 3 or 4, wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, the master PHS terminal device collecting the data pieces from the machines via the slave PHS terminal devices, the master PHS terminal device transmitting the collected data pieces to the center apparatus.

6. A data collection system as recited in claim 3, wherein each of the PHS terminal devices has an entry table of information pieces representing conditions of all the PHS terminal devices.

7. A data collection system as recited in claim 6, wherein each of the PHS terminal devices has a connection table of information pieces representing conditions of radio connections among all the PHS terminal devices.

8. A data collection system as recited in claim 7, wherein the conditions of the radio connections in the connection table are

denoted by numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

9. A data collection system as recited in claim 8, wherein the numeral values in the connection table are determined on the basis of electric-field strengths related to the radio connections.

10. A data collection system as recited in claim 8 or 9, wherein each of the PHS terminal devices deletes a smallest non-zero numeral value from the numeral values in the connection table to change the connection table into a new version, and selects a path of data-piece transmission in response to the new connection table.

11. A data collection system as recited in claim 10, wherein each of the PHS terminal devices deletes a smallest non-zero numeral value from the numeral values in the connection table to change the connection table into a first new version, and wherein each of the PHS terminal devices deletes a smallest non-zero numeral value from the numeral values in the first new connection table to change the first new connection table into a second new version and selects a path of data-piece transmission in response to the second new connection table.

12. A data collection system as recited in claim 11, wherein when each of the PHS terminal devices fails to select a path of data-piece transmission in response to the second new connection table, the

PHS terminal device returns the second new connection table to the first new connection table and selects a path of data-piece transmission in response to the first new connection table.

13. A data collection system as recited in one of claims 10, 11, and 12, wherein each of the PHS terminal devices generates a transmission-path deducing table on the basis of the connection table, and selects a path of data-piece transmission in response to the transmission-path deducing table.

14. A data collection system as recited in claim 8, wherein the PHS terminal devices communicate with each other by radio to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

15. A data collection system as recited in claim 8, wherein the PHS terminal devices communicate with each other by radio in a predetermined sequence and a predetermined rule to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

16. A data collection system as recited in claim 15, wherein different management numbers are assigned to the PHS terminal devices respectively, and each of the PHS terminal devices communicates with only at least one of the PHS terminal devices which has a management number greater than the management

number of the present PHS terminal device to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

17. A data collection system as recited in claim 15, wherein different management numbers are assigned to the PHS terminal devices respectively, and each of the PHS terminal devices communicates with only at least one of the PHS terminal devices which has a management number smaller than the management number of the present PHS terminal device to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

18. A data collection system as recited in claim 16 or 17, wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, and each of the PHS terminal devices communicates with the master PHS terminal device regardless of the management number thereof to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

19. A data collection system as recited in any one of claims 16, 17, and 18, wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, and the master PHS terminal device does not communicate with the other PHS terminal devices to determine the numeral values indicating

degrees of reliabilities of data-piece transmission along the radio connections.

20. A data collection system as recited in any one of claims 14, 15, 16, 17, 18, and 19, wherein each of the PHS terminal devices measures electric-field strengths related to the radio connections, and determines the numerical values on the basis of the measured electric-field strengths.

21. A data collection system as recited in claim 14 or 15, wherein the PHS terminal devices periodically update the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

22. A data collection system as recited in claim 21, wherein the PHS terminal devices periodically update the numeral values by weighted average between previous numerical values and current numerical values.

23. A data collection system as recited in claim 21 or 22, wherein the PHS terminal devices periodically update the numeral values by rewriting information pieces in portions of the connection tables about which the PHS terminal devices communicate with each other by radio to determine the numeral values indicating degrees of reliabilities of data-piece transmission along the radio connections.

24. A data collection system as recited in claim 23, wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, the slave PHS terminal devices transmit the connection tables to the master PHS terminal device, the master PHS terminal device combining the transmitted connection tables into a composite connection table, the master PHS terminal devices transmitting the composite connection table to the slave PHS terminal devices.

25. A data collection system as recited in any one of claims 21, 22, and 24, wherein each of the PHS terminal devices includes a timer for controlling a sequence of execution of operation modes of the related PHS terminal device.

26. A data collection system as recited in claim 23, wherein one of the PHS terminal devices is a master while the other PHS terminal devices are slaves, and wherein one of the slave PHS terminal devices is newly added to the PHS communication network while the other slave PHS terminal devices are old members in the PHS communication network slaves, the newly-added PHS terminal device communicating with one of the old PHS terminal devices to receive the connection table therefrom, the newly-added PHS terminal device communicating with the old PHS terminal devices to generate a new connection table based on the received connection table, and the newly-added PHS terminal device transmitting the new connection table to the master PHS terminal

device.

27. A data collection system as recited in claim 26, wherein all the slave PHS terminal devices including the newly-added PHS terminal device transmit the connection tables to the master PHS terminal device, the master PHS terminal device combining the transmitted connection tables into a revised composite connection table, the master PHS terminal devices transmitting the revised composite connection table to all the slave PHS terminal devices.

28. A data collection system as recited in any one of claims 10, 11, 12, and 13, wherein when plural paths of data-piece transmission from one of the PHS terminal devices are present, one of the plural paths in which a PHS terminal device following a branch has a smaller number is selected.

29. A data collection system as recited in any one of claims 10, 11, 12, and 13, wherein when plural paths of data-piece transmission from one of the PHS terminal devices are present, one of the plural paths which has a smaller number of repeating is selected.

30. A PHS terminal device comprising:

a communication unit for receiving data from a data generating machine;

a memory for storing the received data;

a radio unit for transmitting the data to a PHS communication network by radio; and

means for selecting a path of data transmission in the PHS communication network, and allowing the selected path to be used in the transmission of the data from the radio unit.

31. A data collection system comprising:

a first machine generating a first data piece;

a second machine generating a second data piece;

a first slave PHS terminal device connected to the first machine and receiving the first data piece from the first machine, the first slave PHS terminal device transmitting the first data piece by radio;

a second slave PHS terminal device connected to the second machine and receiving the second data piece from the second machine, the second slave PHS terminal device transmitting the second data piece by radio;

a center apparatus; and

a master PHS terminal device connected to the first slave PHS terminal device via a radio path and receiving the first data piece from the first slave PHS terminal device by radio, the master PHS terminal device being connected to the second slave PHS terminal device via a radio path and receiving the second data piece from the second slave PHS terminal device by radio, the master PHS terminal device being connected to the center apparatus via a public telephone line and transmitting the first data piece and the second

data piece to the center apparatus via the public telephone line.

32. A data collection system as recited in claim 31, further comprising a third machine generating a third data piece, the master PHS terminal device being connected to the third machine and receiving the third data piece from the third machine, the master PHS terminal device transmitting the third data piece in addition to the first and second data pieces to the center apparatus via the public telephone line.

33. A data collection system as recited in claim 31, further comprising a third machine generating a third data piece, and a third slave PHS terminal device connected to the third machine and receiving the third data piece from the third machine, the third slave PHS terminal device transmitting the third data piece by radio, the first slave PHS terminal device being connected to the third slave PHS terminal device via a radio path and receiving the third data piece from the third slave PHS terminal device by radio, the first slave PHS terminal device transmitting the third data piece by radio, the master PHS terminal device receiving the third data piece in addition to the first data piece from the first slave PHS terminal device by radio, the master PHS terminal device transmitting the third data piece in addition to the first and second data pieces to the center apparatus via the public telephone line.

34. A data collection system substantially as herein described with reference to Figures 2 to 22 of the accompanying drawings.

Dated this 3rd day of December 1997

MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
By their Patent Attorney
GRIFFITH HACK

ABSTRACT OF THE DISCLOSURE

A data collection system includes plural machines for generating data pieces respectively. PHS terminal devices are connected to the machines for transmitting the data pieces generated by the machines respectively. The PHS terminal devices compose a PHS communication network. A center apparatus for collecting the data pieces from the machines via the PHS terminal devices. Paths of data-piece transmission are selected in the PHS communication network. The data pieces are transmitted from the machines toward the center apparatus along the selected paths while being repeated by at least one of the PHS terminal devices.

FIG. 1
PRIOR ART

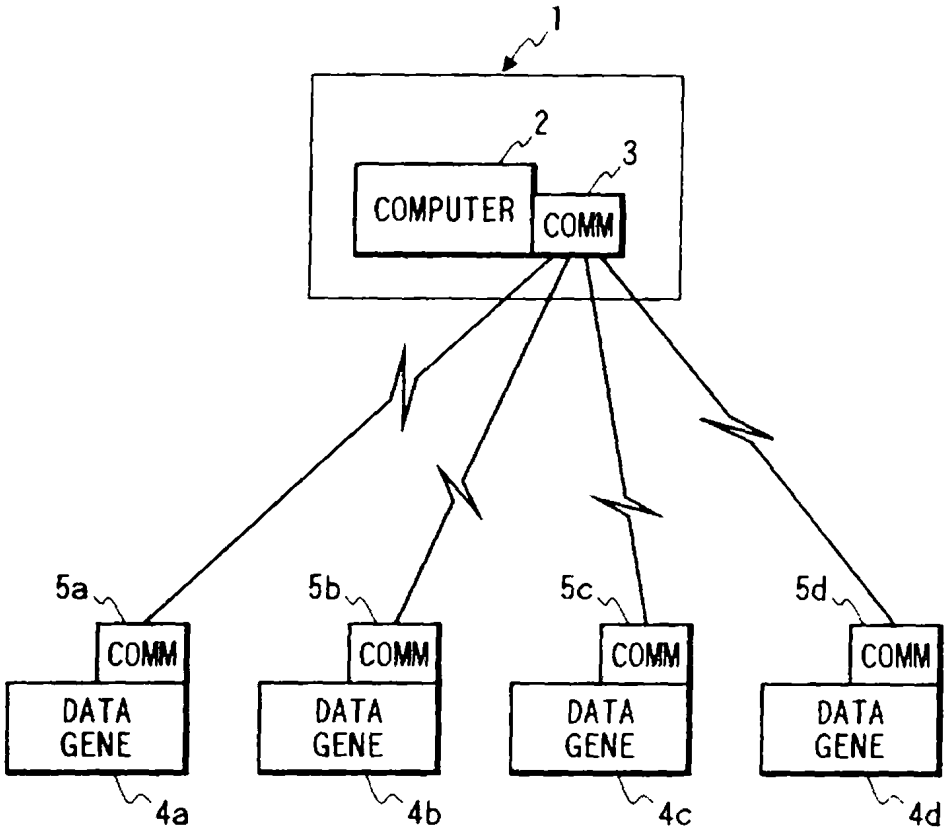


FIG. 2

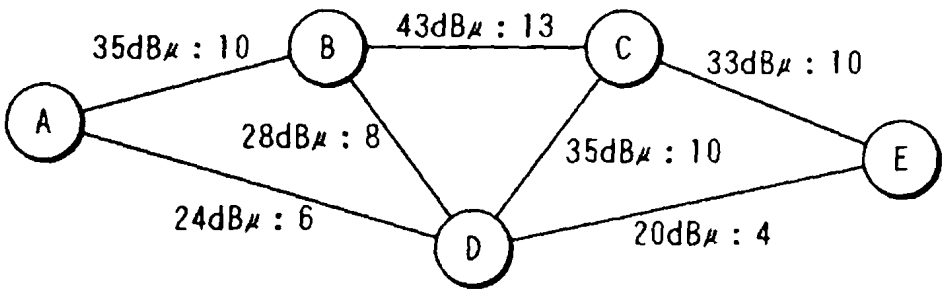


FIG. 3

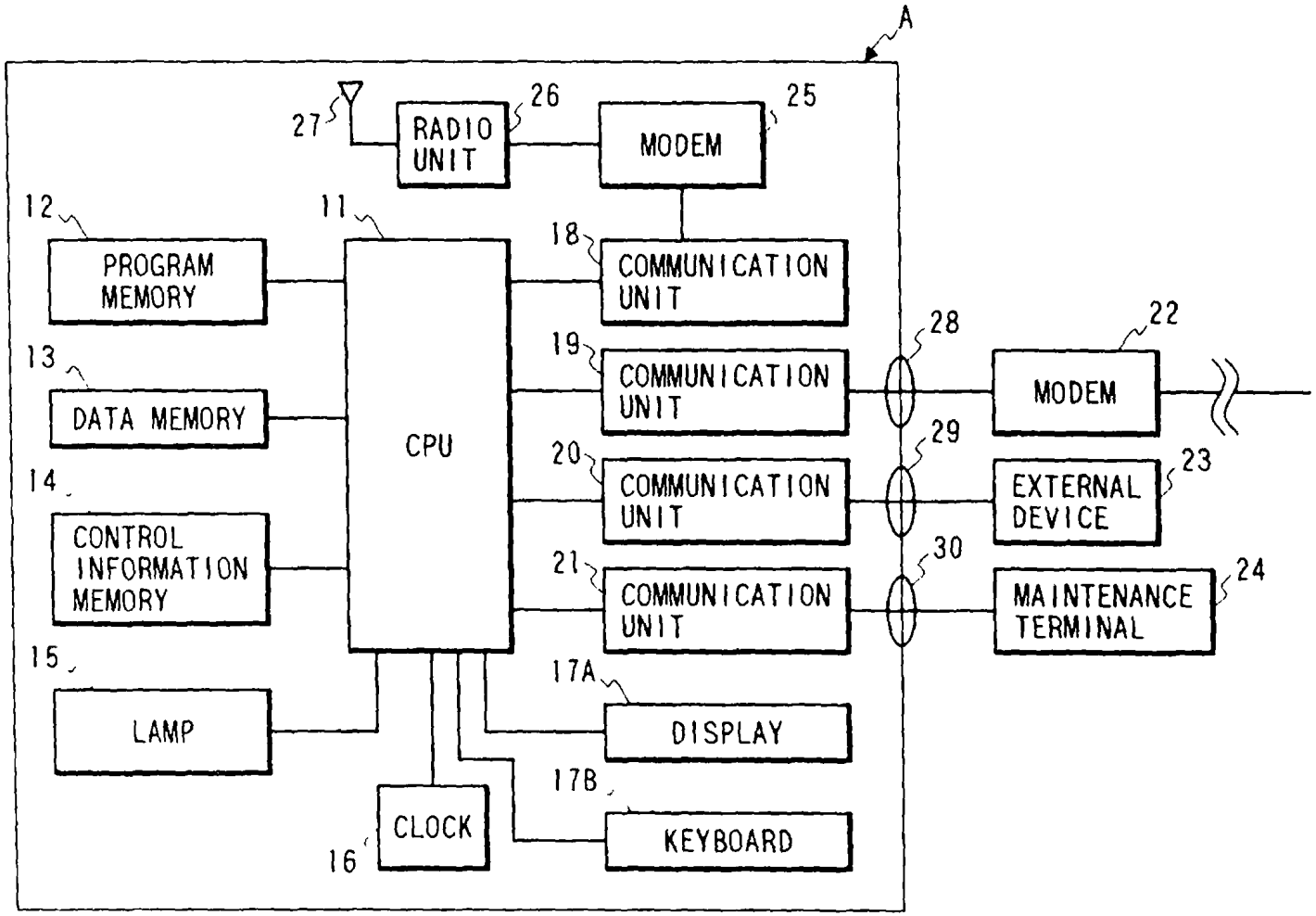

A
27
RADIO UNIT
26
MODEM
25
12
PROGRAM MEMORY
11
CPU
18
COMMUNICATION UNIT
19
COMMUNICATION UNIT
20
COMMUNICATION UNIT
21
COMMUNICATION UNIT
28
22
MODEM
29
23
EXTERNAL DEVICE
30
24
MAINTENANCE TERMINAL
13
DATA MEMORY
14
CONTROL INFORMATION MEMORY
15
LAMP
16
CLOCK
17A
DISPLAY
17B
KEYBOARD

FIG. 4

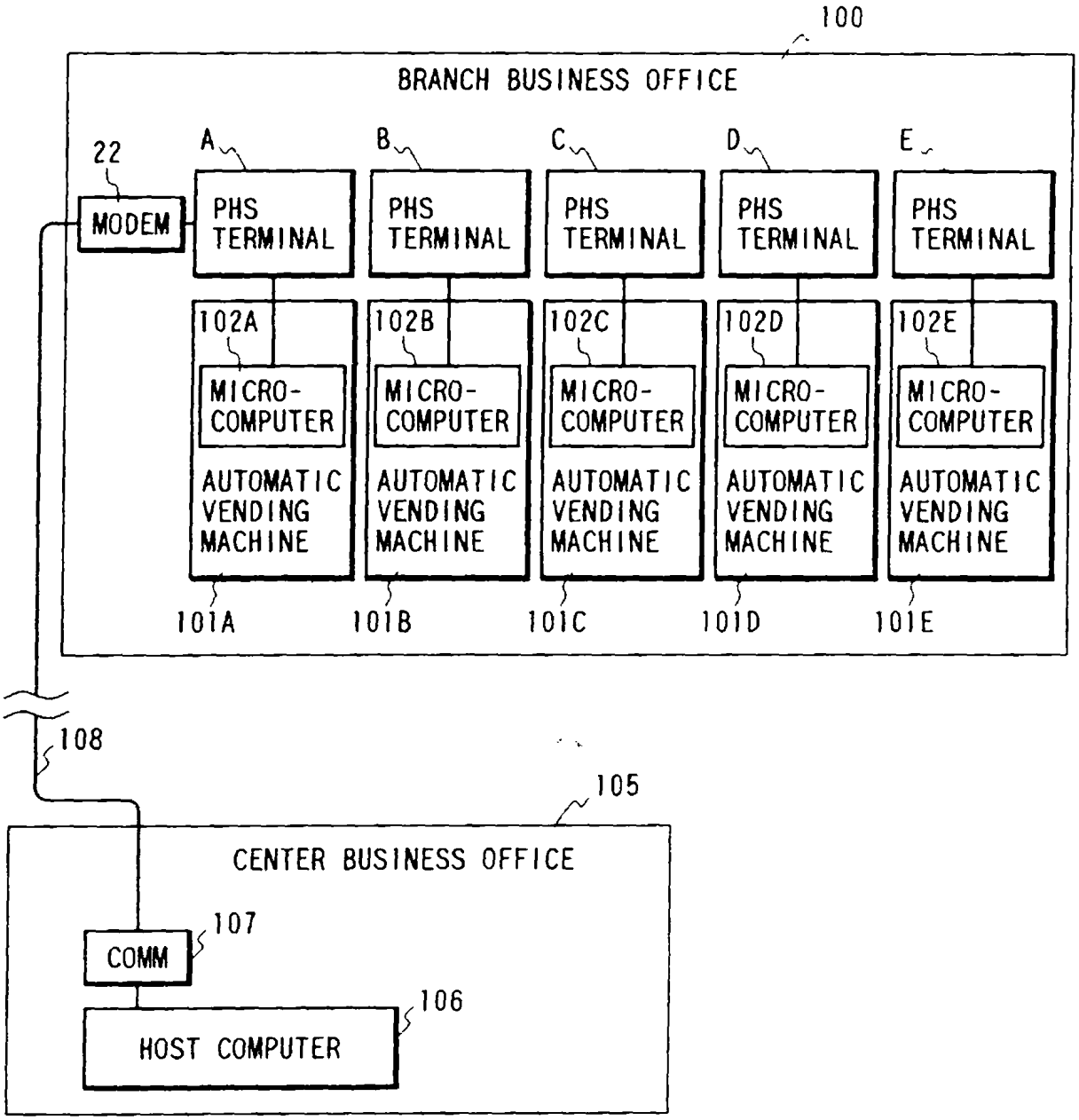

100
BRANCH BUSINESS OFFICE
22
MODEM
A
B
C
D
E
PHS TERMINAL
PHS TERMINAL
PHS TERMINAL
PHS TERMINAL
PHS TERMINAL
102A
102B
102C
102D
102E
MICRO-COMPUTER
MICRO-COMPUTER
MICRO-COMPUTER
MICRO-COMPUTER
MICRO-COMPUTER
AUTOMATIC VENDING MACHINE
AUTOMATIC VENDING MACHINE
AUTOMATIC VENDING MACHINE
AUTOMATIC VENDING MACHINE
AUTOMATIC VENDING MACHINE
101A
101B
101C
101D
101E
108
105
CENTER BUSINESS OFFICE
107
COMM
106
HOST COMPUTER

FIG. 5

41

ENTRY NUMBER	MANAGEMENT NUMBER	PS NUMBER	DEVICE TYPE
1	6(C)	16	SLAVE
2	10(A)	21	MASTER
3	18(B)	39	SLAVE
4	21(E)	42	SLAVE
5	25(D)	47	SLAVE

41a 41b 41c 41d

FIG. 6

42

DEVICE	A	B	C	D	E
A	—	10	0	6	0
B	10	—	13	8	0
C	0	13	—	10	10
D	6	8	10	—	4
E	0	0	10	4	—

FIG. 7

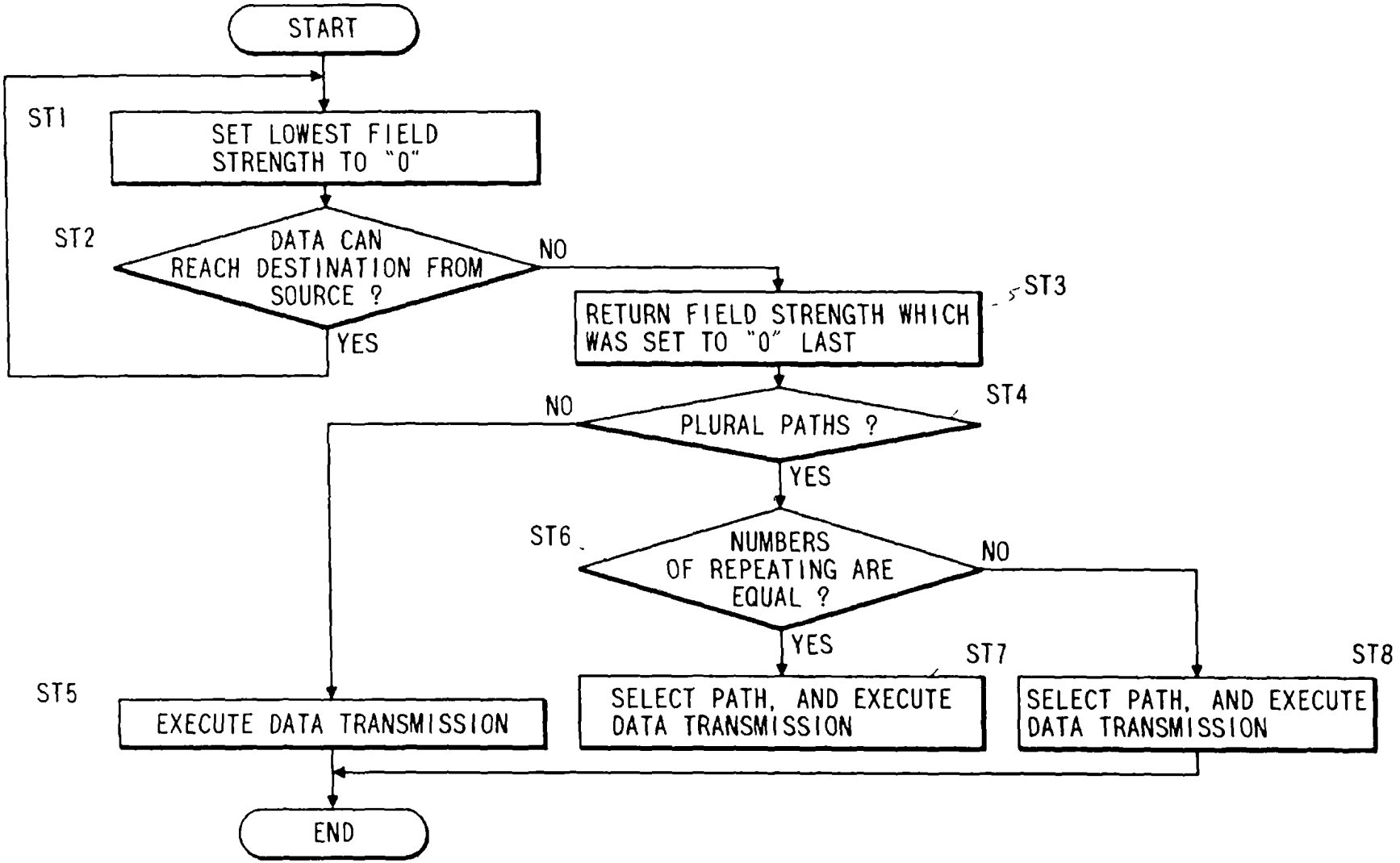

START
ST1
SET LOWEST FIELD STRENGTH TO "0"
ST2
DATA CAN REACH DESTINATION FROM SOURCE ?
NO
YES
ST3
RETURN FIELD STRENGTH WHICH WAS SET TO "0" LAST
ST4
NO
PLURAL PATHS ?
YES
ST6
NUMBERS OF REPEATING ARE EQUAL ?
NO
YES
ST5
EXECUTE DATA TRANSMISSION
ST7
SELECT PATH, AND EXECUTE DATA TRANSMISSION
ST8
SELECT PATH, AND EXECUTE DATA TRANSMISSION
END

FIG. 8

DEVICE	A	B	C	D	E
A	—	10	0	6	0
B	10	—	13	8	0
C	0	13	—	10	10
D	6	8	10	—	0
E	0	0	10	0	—

FIG. 9

DEVICE	A	B	C	D	E
A	—	10	0	0	0
B	10	—	13	8	0
C	0	13	—	10	10
D	0	8	10	—	0
E	0	0	10	0	—

FIG. 10

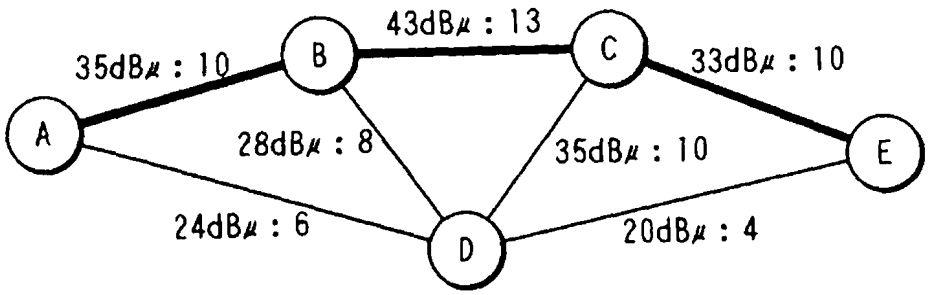


FIG. 11

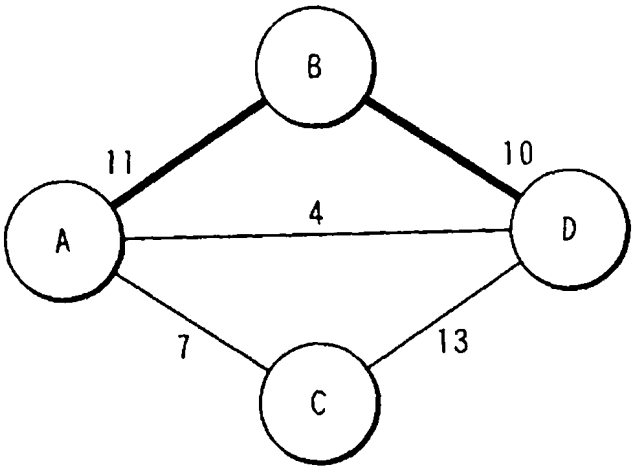


FIG. 12

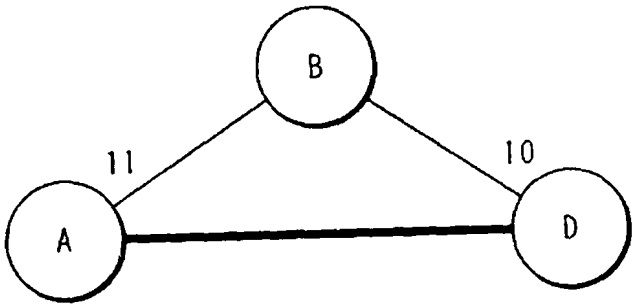


FIG. 13

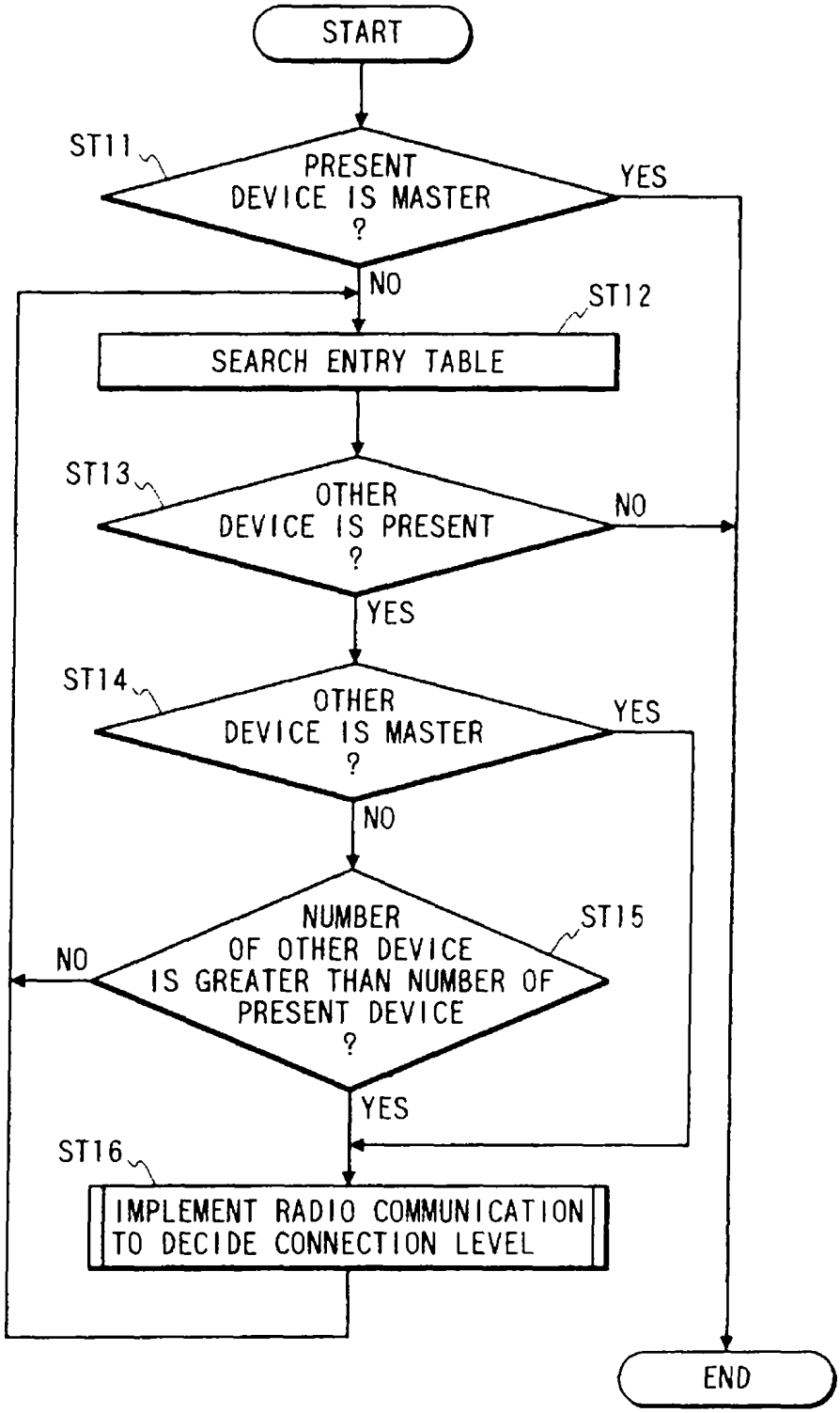

START
ST11
PRESENT DEVICE IS MASTER ?
YES
NO
ST12
SEARCH ENTRY TABLE
ST13
OTHER DEVICE IS PRESENT ?
NO
YES
ST14
OTHER DEVICE IS MASTER ?
YES
NO
ST15
NUMBER OF OTHER DEVICE IS GREATER THAN NUMBER OF PRESENT DEVICE ?
NO
YES
ST16
IMPLEMENT RADIO COMMUNICATION TO DECIDE CONNECTION LEVEL
END

FIG. 14

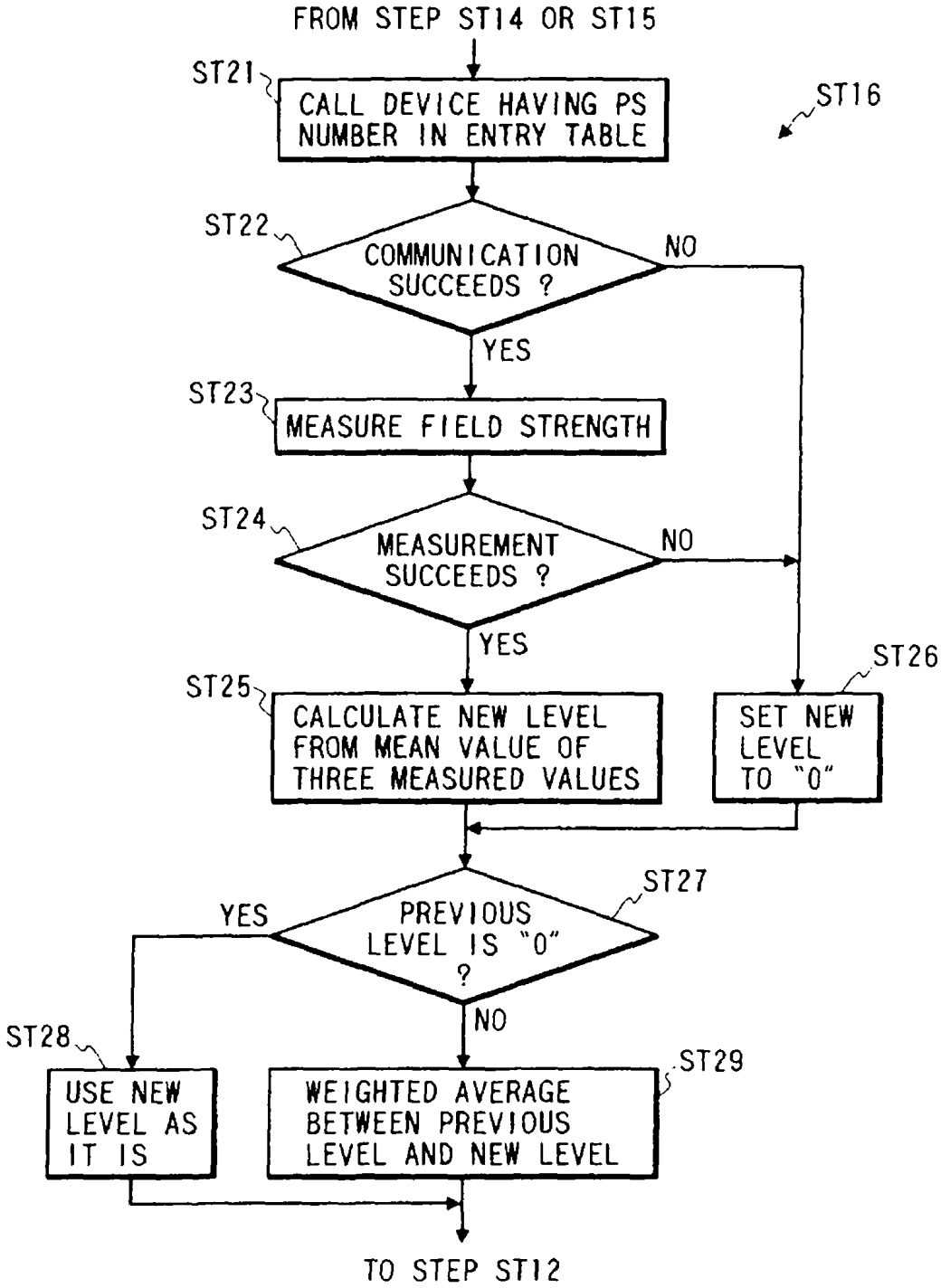

FROM STEP ST14 OR ST15
ST21
CALL DEVICE HAVING PS NUMBER IN ENTRY TABLE
ST16
ST22
COMMUNICATION SUCCEEDS ?
NO
YES
ST23
MEASURE FIELD STRENGTH
ST24
MEASUREMENT SUCCEEDS ?
NO
YES
ST25
CALCULATE NEW LEVEL FROM MEAN VALUE OF THREE MEASURED VALUES
ST26
SET NEW LEVEL TO "0"
ST27
PREVIOUS LEVEL IS "0" ?
YES
NO
ST28
USE NEW LEVEL AS IT IS
ST29
WEIGHTED AVERAGE BETWEEN PREVIOUS LEVEL AND NEW LEVEL
TO STEP ST12

FIG. 15

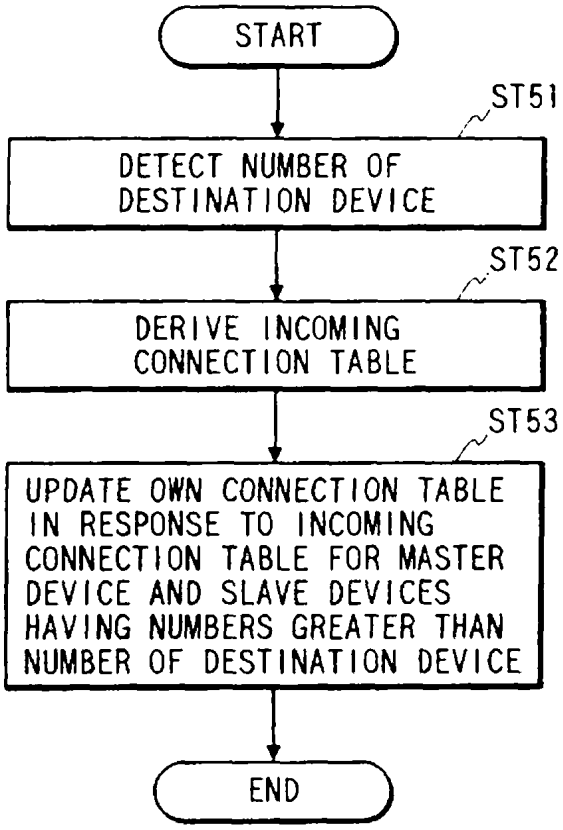

START
ST51
DETECT NUMBER OF DESTINATION DEVICE
ST52
DERIVE INCOMING CONNECTION TABLE
ST53
UPDATE OWN CONNECTION TABLE IN RESPONSE TO INCOMING CONNECTION TABLE FOR MASTER DEVICE AND SLAVE DEVICES HAVING NUMBERS GREATER THAN NUMBER OF DESTINATION DEVICE
END

FIG. 16

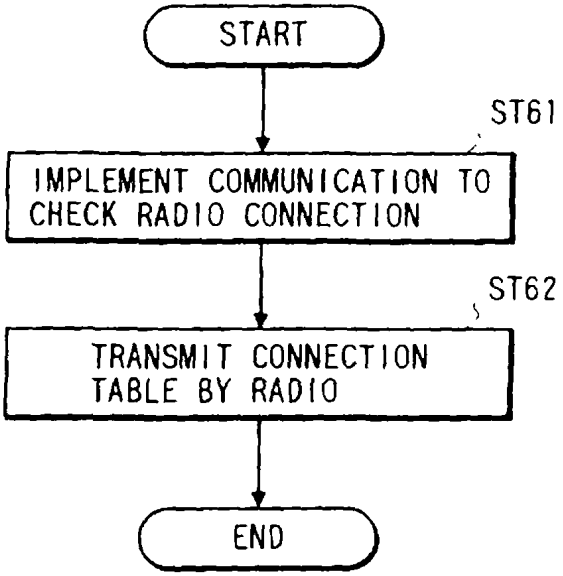

START
ST61
IMPLEMENT COMMUNICATION TO CHECK RADIO CONNECTION
ST62
TRANSMIT CONNECTION TABLE BY RADIO
END

FIG. 17

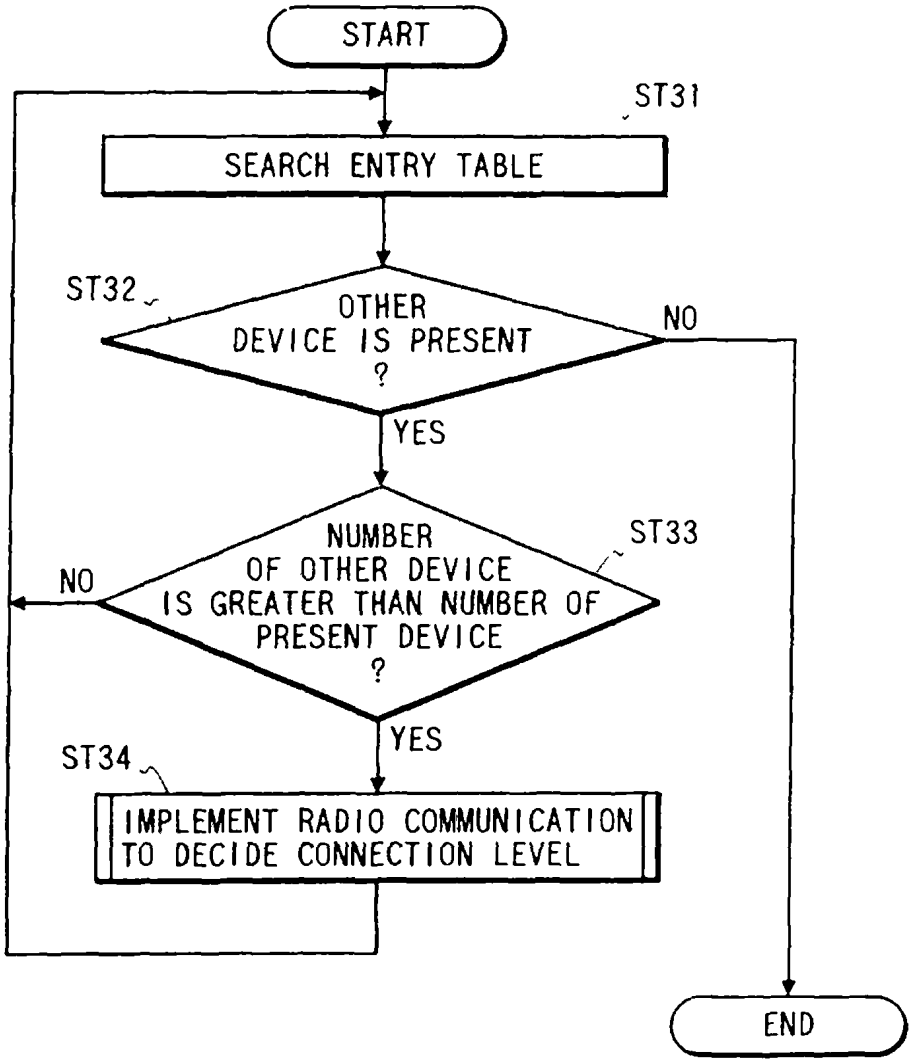

START
ST31
SEARCH ENTRY TABLE
ST32
OTHER DEVICE IS PRESENT ?
NO
YES
NUMBER OF OTHER DEVICE IS GREATER THAN NUMBER OF PRESENT DEVICE ?
ST33
NO
YES
ST34
IMPLEMENT RADIO COMMUNICATION TO DECIDE CONNECTION LEVEL
END

FIG. 18

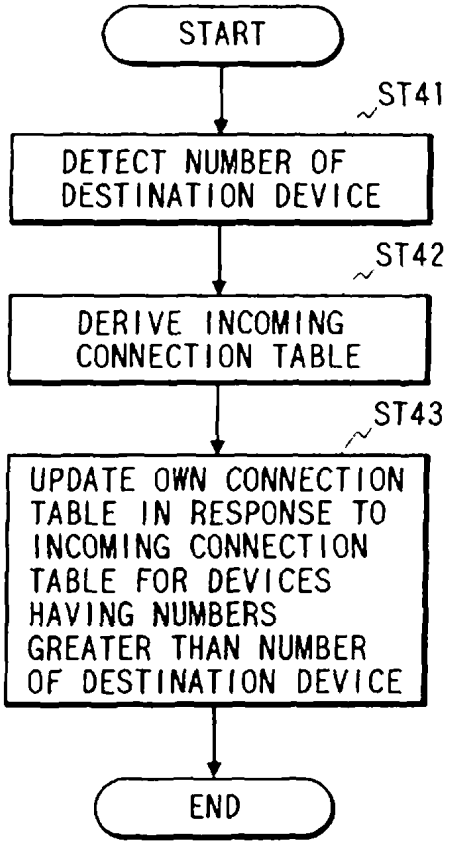

START
ST41
DETECT NUMBER OF DESTINATION DEVICE
ST42
DERIVE INCOMING CONNECTION TABLE
ST43
UPDATE OWN CONNECTION TABLE IN RESPONSE TO INCOMING CONNECTION TABLE FOR DEVICES HAVING NUMBERS GREATER THAN NUMBER OF DESTINATION DEVICE
END

FIG. 19

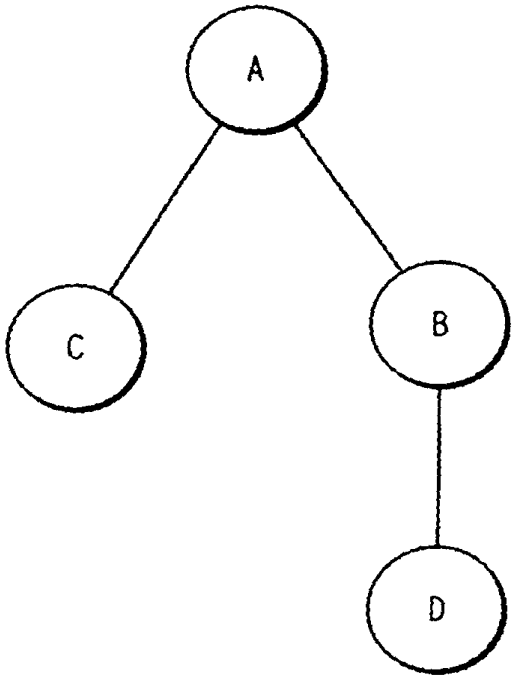


FIG. 21

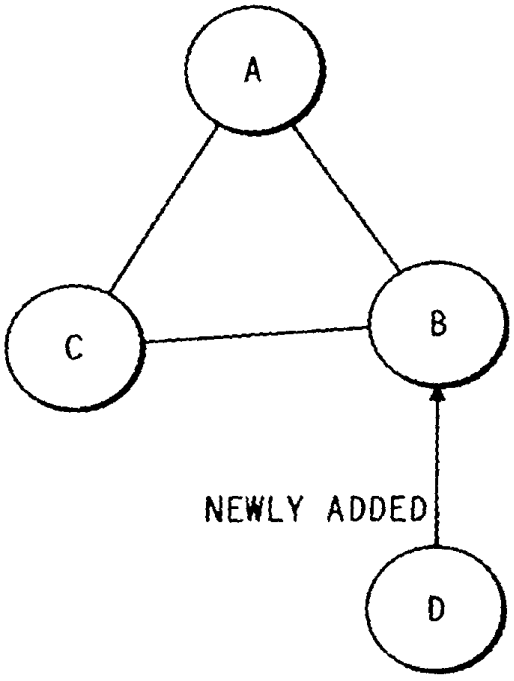


FIG. 20

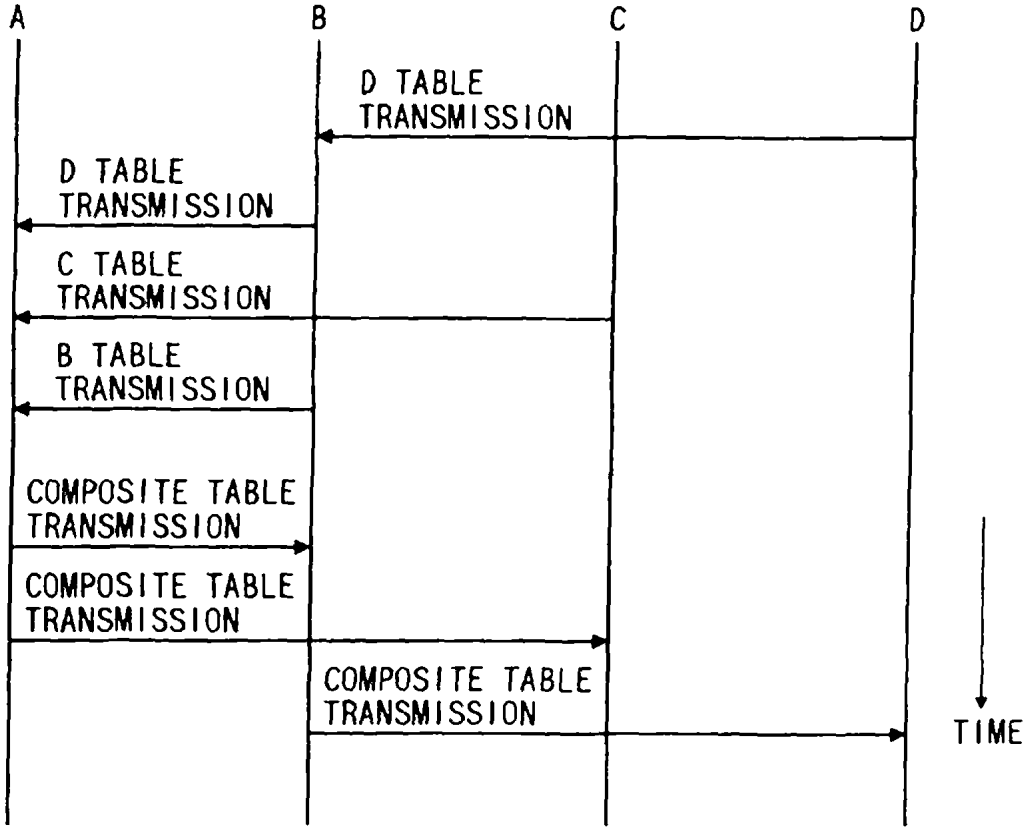
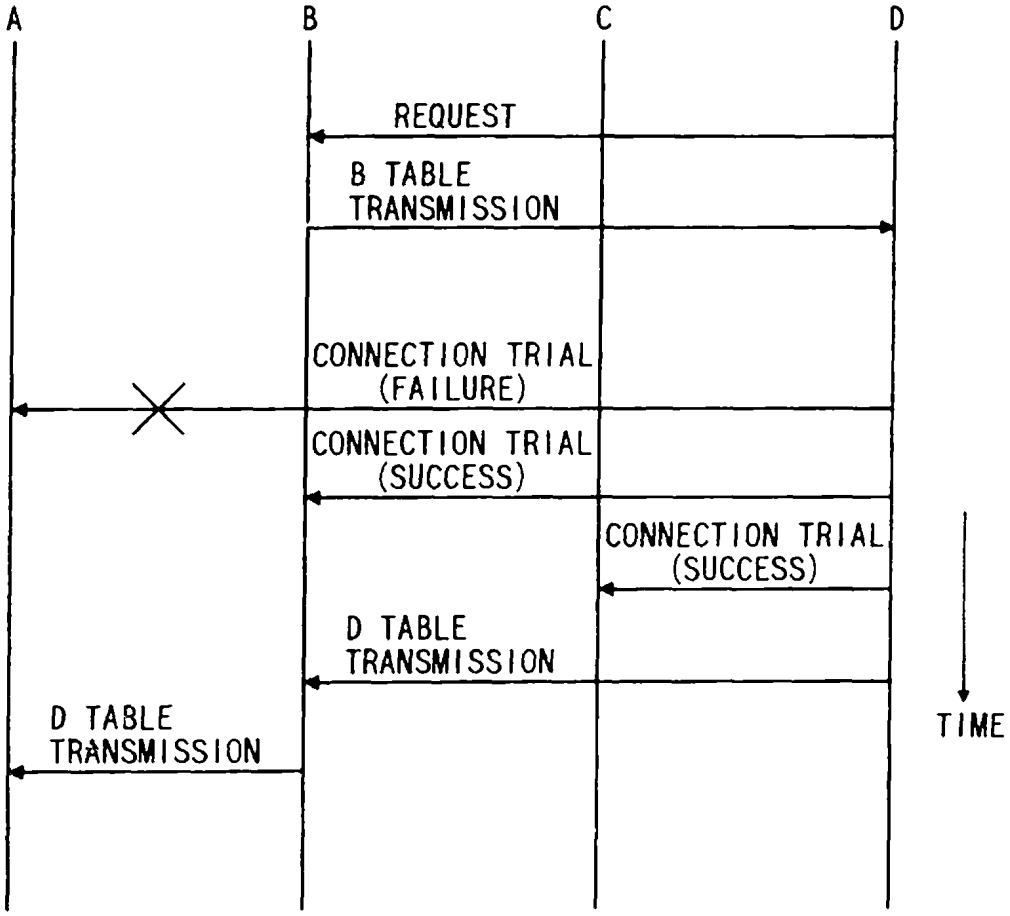

A
B
C
D
D TABLE TRANSMISSION
D TABLE TRANSMISSION
C TABLE TRANSMISSION
B TABLE TRANSMISSION
COMPOSITE TABLE TRANSMISSION
COMPOSITE TABLE TRANSMISSION
COMPOSITE TABLE TRANSMISSION
TIME

FIG. 22


A
B
C
D
REQUEST
B TABLE TRANSMISSION
CONNECTION TRIAL (FAILURE)
CONNECTION TRIAL (SUCCESS)
CONNECTION TRIAL (SUCCESS)
D TABLE TRANSMISSION
D TABLE TRANSMISSION
TIME